USSR Report

PHYSICS AND MATHEMATICS

19980715 116

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

JPRS-UPM-87-004

8 APRIL 1987

USSR REPORT

PHYSICS AND MATHEMATICS

CONTENTS

ACOUSTICS

LASERS

MAGNETOHYDRODYNAMICS

OPTICS AND SPECTROSCOPY

NUCLEAR PHYSICS

/9835

UDC 537.86

COHERENT COMBINATION REFLECTION OF ELECTROMAGNETIC WAVES BY AGITATED
INTERFACE BETWEEN TWO MEDIA SUBJECTED TO ACOUSTIC RADIATION

[Article by Yu.P. Dyakov, I.B. Yesipov, K.K. Lyapin, K.A. Naugolnykh,
N.I. Pozdiyakov, and V.I. Sokolov, Acoustics Institute imeni N.N. Andreev,
USSR Academy of Sciences]

[Abstract] The interaction of electromagnetic and acoustic waves on a
statistically uneven surface is investigated. It is demonstrated
theoretically, and proved experimentally, that one of the combination
components of the scattered electromagnetic field during such interaction
may turn out to be phase-stable and "disregard" irregularities of the inter-
face boundary and their movement. In this way, that component retains the
coherence of the incident field, which causes some portion of the electro-
magnetic field to be re-radiated by the illuminated section of the surface
with a high degree of directivity, as if reflection rather than scattering
were occurring. The effects observed experimentally agree entirely with
the predictions of the theory that has been developed for coherent combina-
tion reflection from a statistically uneven surfaces. Figures 3;
references 10: 9 Russian, 1 Western.

6900/9835
CSO: 1862/235

EXPERIMENTAL INVESTIGATION OF ACOUSTIC SCATTERING BY LAYER OF SPHERICAL
BODIES

[Article by N.N. Dmitrevskiy, Yu.Yu. Zhitkovskiy, and A.V. Kulikov]

[Abstract] The angular characteristics of backscattering of sound by a
monolayer of separate spheres are investigated experimentally disregarding
the influence of the underlying surface. A set of identical spheres whose
centers lie in the same plane and whose diameter is shorter than the
acoustic wavelength is used as the theoretical model. It can be assumed as
a first approximation that when a sound wave strikes this surface each of
the spherical bodies will act as an individual scatterer that is unrelated
with the others, and the amplitudes of the signals reflected from each
sphere will be the same, so that the problem is to sum a large number of
harmonic signals with the same frequency but with different phases. A
formula is derived that can be used as the basis for remote acoustic
sounding of the ocean floor. Figures 6; references 6: 3 Russian,
3 Western.

6900/9835
CSO: 1862/235

ACOUSTIC DIAGNOSIS OF VIBRATIONALLY ACTIVE MECHANISMS BY RECIPROCITY METHODS

[Article by P.I. Korotin, B.M. Salin, and V.A. Tyutin, Institute of
Applied Physics, USSR Academy of Sciences]

[Abstract] Diagnosis of vibrationally active mechanisms on the basis of
reciprocity is demonstrated, such a method being expedient where direct
measurement of emitted noise will not serve the purpose because of high
interference levels and simultaneous operation of several mechanisms. A
reciprocity test involves placing a calibrated sound source, generally a
wideband one but in some cases a monochromatic one, at the point where the
noise field is to be analyzed and measuring the velocities and forces or
moments it generates in individual mechanisms. The validity of diagnosis on
the basis of such a test derives from a one-to-one relation between the
vibration parameters of noise generating mechanisms and sound pressure
signals in discrete narrow bands characterizing the acoustic field, complex

amplitudes being the measured quantities. This relation is established
here from the system of equations describing an acoustomechanical system
making contact with a base or foundation at a given number of points.
Accuracy and reliability of a reciprocity test can be ensured by a sufficiently
high power of the sound source. This method of diagnosis will then be
applicable even where the signal-to-interference ratio is smaller than
unity, and the results will be useful for in the design of mountings for
maximum vibration isolation. References 12: 6 Russian, 6 Western.

2415/9835
CSO: 1862/163

ACOUSTIC TURBULENCE IN SUPERFLUID HELIUM

[Article by S.K. Nemirovskiy, Energokhimmash Special Design Bureau]

[Abstract] Acoustic turbulence is investigated in He II, which exhibits
interaction among uncorrelated acoustic waves as well as cross-effects
between the first and second harmonics. A steady-state scale-invariant
solution is derived for the kinetic equations for paired complex amplitude
correlators, and the acoustic properties of turbulent He II are described.
The solutions obtained are used to compute the attenuation and dispersion
of acoustic waves propagating through helium containing random wave fields.
A discussion of the criterion and numerical estimates employed is presented.
Figures 6; references 11: 10 Russian, 1 Western.

6900/9835
CSO: 1862/258

CRYSTALS, LASER GLASSES, SEMICONDUCTORS

CONTRIBUTION OF INTERSTITIAL TUNNELING TO MOBILITY OF SMALL-RADIUS POLARON
IN DISORDERED SYSTEMS

[Article by V.V. Bryskin, Institute of Engineering Physics imeni A.F. Ioffe,
USSR Academy of Sciences, Leningrad]

[Abstract] Interstitial tunneling in disordered systems with a Fermi level
below the mobility limit is analyzed on the basis of the small-radius
polaron model, of particular concern being its role in charge transport
by the mechanism of phonon-induced transitions between localized electron
states. A grid of random impedances is used for calculating the electrical
conductivity of such a system at the static limit in the linear (Ohm's
law) approximation for the electric field. On this basis are determined
the probabilities of transitions, the tunneling component of electrical
conductivity, and the critical cluster dimension for correlated current
flow. The temperature dependence of the electrical conductivity log
o = f(1/T) indicates a dominant tunneling component below some temperature
T_2 and a dominant hopping component above some temperature T_1. Polaron
transport has been observed in some amorphous oxides (TiO_2, Nb_2O_5, Ta_2O_5).
Figures 3; references 21: 7 Russian, 14 Western (1 in Russian translation).

OPTOACOUSTIC INTERACTION IN SEMICONDUCTORS AND PHASE CONJUGATION OF SOUND BEAMS

[Article by V.N. Strel'tsov, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] A new mechanism of optoacoustic interaction in semiconductors is examined, namely phonon-plasmon interaction during time-dependent modulation of the conduction-band electron concentration by a periodic sequence of light pulses. The process is analyzed, assuming an infinitely large semiconductor layer with a sufficiently strong electron-phonon bond established through the deformation potential. A longitudinal sound wave of frequency ω impinges on this layer, normally incident, while the latter is uniformly illuminated by a sequence of light pulses with period $T = \pi/\omega$ and intensity $I(t)$ variable in time. Propagation of the sound wave through the semiconductor layer generates Langmuir oscillations in the electron plasma so that the plasma density will alternate at frequency 2ω and emit a reverse sound wave of frequency ω parametrically interacting with the incident one. Calculations based on the stress tensor and the strain polarization vector reveal that the interaction of the two sound waves results in an energy transfer from the incident one to the reflected one with reversed wave front. References 3: 2 Russian, 1 Western.

GENERATION OF Ho IONS BY $^5I_7 \to {}^5I_8$ TRANSITION AT ROOM TEMPERATURE IN Cr^{3+}, Tm^{3+}, Ho^{3+}-DOPED Y-Sc-Ga GARNET CRYSTAL

[Article by A.N. Alpatyev, Ye.V. Zharikov, S.P. Kalitin, V.V. Laptev, V.V. Osiko, V.G. Ostroumov, A.M. Prokhorov, Z.S. Saidov, V.A. Smirnov, I.T. Sorokina, A.F. Umyskov, and I.A. Shcherbakov, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] Free emission at the $^5I_7 \to {}^5I_8$ transition of Ho^{3+} ions in a Y-Sc-Ga garnet crystal was attained, at room temperature, by optical pumping of such a crystal as the active medium containing Cr^{3+}, Tm^{3+}, Ho^{3+} ions as activators in concentrations of $2.5 \cdot 10^{20}$ cm^{-3}, $8 \cdot 10^{20}$ cm^{-3}, $0.5 \cdot 10^{20}$ cm^{-3} respectively. The active medium in the experiment was a 74 mm long cylindrical crystal 5.5 mm in diameter, a 0.1% aqueous solution

of K_2CrO_4 acting as coolant fluid and ultraviolet filter. The resonator was formed by an Au-coated opaque spherical mirror with radius R = 1.5 m and a 0.38 mm thick plane-parallel Si plate operating in the Fresnel reflection mode. The pump was an ISP-2500 Xe lamp, in an Ag-coated quartz container, emitting flashes at a repetition rate of 1 Hz. Measurement of the laser emission energy as a function of the pumping energy revealed a 125 J threshold and a 1.1% differential efficiency. Pumping with 500 J pulses produced emission of 4 J pulses (0.8% absolute efficiency) at the λ = 2.088 µm wavelength, still within the linear range of the performance curve. Figures 2; references 9: 6 Russian, 3 Western.

STRUCTURAL EXAMINATION OF GaAs SURFACE BY METHOD OF ASYMPTOTIC BRAGG DIFFRACTION

[Article by V.A. Chaplanov and S.S. Yakimov]

[Abstract] A structural examination of the transition layer between a perfect GaAs crystal and a natural oxide film on its (111) and (111) surfaces was done by the method of asymptotic Bragg diffraction, namely by measuring the intensity of an x-ray beam diffractively reflected by the crystal far from the Bragg angle so that $\Delta\theta = \theta-\theta_B >> \theta_0$ (θ — beam incidence angle, θ_B — Bragg angle, θ_0 — natural half-width of Bragg reflex). Interference of rays reflected by deeper layers causes their mutual suppression, and the reflection coefficient is determined their scattering by the $L = \lambda/4\pi\cos\theta_B\Delta\theta$ deep surface layer (— wavelength of x-radiation). The "real" GaAs surface in the experiment had been obtained as a result of chemical and mechanical polishing with subsequent chemical etching and storage in air. It was oriented parallel to the (111) planes of the crystal and exposed to CuK_α-line radiation (wavelength λ = 1.54 Å). The results of this examination reveal a difference between the Ga side and the As side of the transition layer, attributable to relaxation of that layer. A model of the GaAs is constructed on this basis, taking into account the not purely covalent bond in this $A^{III}B^V$ compound and the stronger attraction of electrons to the positively charges As so that oxygen atoms will more strongly interact with As atoms. The deformed layer becomes thicker on the As side and thinner on the Ga side, which causes relaxation of the crystal surface on the Ga side. The authors thank A.M. Afanasyev for interest, S.S. Fanchenko for helpful discussions, and B.G. Zakharov for supplying the specimens and discussing the results. Figures 2; references 5: 3 Russian, 2 Western.

NONLINEAR RELAXATIONAL ABSORPTION OF ULTRASOUND IN SEMICONDUCTORS WITH
HOPPING CONDUCTION

[Article by Yu.M. Gal'perin and E.Ya. Priyev, Institute of Engineering
Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Nonlinear absorption of ultrasound by semiconductors in absence
and in presence of a magnetic field is analyzed theoretically, relaxation
being the dominant absorption mode already at low acoustic power levels
because of its much higher nonlinearity threshold than that of the resonance
absorption mode. Weakly doped n-type semiconductors are considered,
absorption here being, in accordance with the two-node model, determined
by hopping of electrons between donors farther apart than the localization
radius. Both a piezoelectric material and an amorphous or other nonpiezo-
electric one are considered, absorption of acoustic waves being associated
with piezoelectric interaction in the former and principally with deforma-
tion in the latter. The absorption coefficient is in each case calculated
in two steps, determination of the absorption power of one donor pair being
followed by summation (integration) over all donor pairs, on the basis of
the equation of kinetics for the population of a pair's upper level. On
account of the nonlinearity, it is in each case calculated separately for
the three relevantly defined low-frequency, intermediate-frequency, and
high-frequency ranges. References 11: 6 Russian, 5 Western.

GENERATION OF F-CENTERS IN KBr BY PICOSECOND ELECTRON PULSES

[Article by E.D. Aluker, B.Z. Gorbenko, R.G. Deych, G.S. Dumbadze,
A.D. Tal'virskiy, and V.G. Shpak, Institute of Physics, LaSSR Academy of
Sciences, Salaspils]

[Abstract] An experimental study was made concerning generation of F-centers
in crystals of alkali halides such as KBr by picosecond electron pulses,
nanosecond pulses not being sufficiently short and thus not offering a
sufficient time resolution for tracking radiative defect formation over
a wide temperature range. The excitation source in the experiment was a
high-current electron accelerator with a peaking circuit which put out

subnanosecond pulses of high-energy electrons. The 350 keV electron beam was led into a cryostat containing a 10x5x1 mm^3 large KBr crystal. The probing light beam from an ISSh-300 flash lamp was recorded in an Agat-SF electron-optical chamber. Measurements were made at temperatures of 80 K and 300 K, revealing the relaxation kinetics of F-center absorption in KBr at those temperatures. The results and extrapolated other available data indicate that the efficiency of F-center generation does not depend on the temperature over the 5-500 K range. Figures 1; references 6: 1 Russian, 5 Western.

2415/9835
CSO: 1862/54

EFFECT OF PRESSURE (DENSITY) RISE ON LUMINESCENCE AND OTHER ELECTRONIC PHENOMENA IN GLASSY SYSTEMS

[Article by M.I. Klinger, Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Changes in electronic properties including luminescence of amorphous glass as a result of a pressure rise causing a rise of its density to nearly that of crystalline glass are analyzed on the basis of semiconductor theory with self-localization of electron (hole) pairs on soft atomic configurations, taking into consideration optical absorption at the ground level and within the gap, photoluminescence threshold and peak, Stokes shift, and conductivity activation. Calculations for the two cases of $\alpha_2 V_0 < 1/2 E_g \alpha_1$ ($\alpha_2 < 0$ or $\alpha_2 > 0$) and $\alpha_2 V_0 > 1/2 E_g \alpha_1$ involve the corresponding energy parameters as functions of the pressure and the equation of state describing the density as a function of pressure, temperature, and some other parameters. References 9: 2 Russian, 7 Western.

2415/9835
CSO: 1862/51

8

COMPOUND SEMICONDUCTORS OF II-IV-V$_2$ CLASS: PHYSICAL RESEARCH, PROBLEMS, AND POSSIBLE APPLICATIONS

[Article by V.M. Tuchkevich, academician, recipient of Lenin and State prizes]

[Abstract] Research on II-IV-V$_2$ ternary compound semiconductor materials began in the USSR in the middle nineteen sixties, at the Institute of Physics imeni A.F. Ioffe (USSR Academy of Sciences) under the leadership of N.A. Goryunova. Results of more recent theoretical and experimental studies made in the USSR and abroad concerning applications for these materials as well as their physics and technology are reviewed in this issue of IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: FIZIKA by A.S. Poplavoy ("Lattice Dynamics and Chemical Bonds in II-IV-V$_2$ Semiconductor Compounds"), V.A. Chaldyshev and N.A. Zakharov ("Band Structure and Optical Properties of II-IV-V$_2$ Compounds"), G.A. Babonas, S.A. Martsinkyavichyus, and A.Yu. Shileyka ("Birefringence and Gyrotropy of II-IV-V$_2$ Compounds"), V.V. Sobolev and V.Ye. Grachev ("Optical Functions and Energy Bands of II-IV-V$_2$ Phosphides"), Yu.V. Rud' ("Photopleochroism and Physical Principles of Semiconductor-Tyep Polarimetric Photodetectors"), V.N. Brudnyy ("Radiative Defects in II-IV-V$_2$ Semiconductor Compounds"), M.I. Daunov, A.B. Magomedov, and A.E. Ramazanova ("Effect of Hydrostatic Pressure on Electron Energy Spectrum and Kinetic Properties of II-IV-V$_2$ Semiconductors"), A.V. Anshon, I.A. Karpovich, A.A. Safonov ("Heterojunctions Based on II-IV-V$_2$ and II-V Compounds"), and V.N. Brudnyy, V.A. Novikov, and Ye.A. Popova ("Electrical and Optical Properties of Electron-Bombarded ZnGeP$_2$ Compound").

RADIATIVE DEFECTS IN II-IV-V$_2$ SEMICONDUCTOR COMPOUNDS

[Article by V.N. Brudnyy, Siberian Institute of Engineering Physics imeni V.D. Kuznetsov, Tomsk State University]

[Abstract] Radiative defects in II-IV-V$_2$ compound semiconductors and physicochemical changes they produce are reviewed on the basis of physical research done so far and from the standpoint of their predictability for technological purposes. Theoretical analysis is facilitated by referring each II-IV-V$_2$ ternary compound to its already well known electronic or

electronic-nuclear II-V binary analog. Data on the electrical resistivity of intrinsic as well as p-type or n-type $CdSnAs_2$, $ZnSnAs_2$, $CdGeAs_2$, $ZnGeAs_2$, $CdSiAs_2$, $ZnSiAs_2$, $GaAs-ZnGeAs_2$ and $GaAs-ZnSiAs_2$ solid solutions, $ZnGeP_2$, $CdSnP_2$, $CdSiP_2$, $CdGeP_2$, $ZnSnP_2$, $ZnSnSb_2$ before and after bombardment by electrons, hydrogen or deuterium ions at 300 K and some also at 77 K are presented and interpreted. The problem of annealing such defects, especially after low-temperature (77 K) bombardment, has not yet been thoroughly enough studied. Very important will be a precise determination of "limiting" electrical characteristics not only of many ternary compounds but also of some binary ones. Figures 8; tables 2; references 70: 35 Russian, 35 Western.

2415/9835
CSO: 1862/46

INTERION INTERACTION IN αβ-SrF_2-2YF_3 SYSTEM AND POPULATION KINETICS OF $^5I_7$ TERM OF HOLMIUM

[Article by A.M. Gkachuk, S.I. Klokishner, and M.V. Petrov]

[Abstract] The characteristics of inter-center transitions and transfer processes during interion interaction in αβ-SrF_2-2YF_3 crystals are investigated. Radiative and non-radiative inter-center relaxation are investigated experimentally and theoretically. The cross-relaxation transfer rates are determined, and the population kinetics of the $^5I_7$ term of Holmium is investigated. The $^5I_7$ term in αβ-SrF_2-2YF_3 crystals is found to be populated effectively as the result of a series of independent cross-relaxation processes that proceed at characteristic rates. With pulse pumping, these processes facilitate "automatic pumping" of the $^5I_7$ working level and make it possible to achieve population inversion at different times, thus permitting a series of oscillation spikes to be observed that are delayed by different amounts with respect to the pumping pulse. The specific type of oscillation of Holmium in the presence of sensitizers is determined by the relationship between the probabilities of the inter-center transitions and inter-ion interaction in the system in question. Tables 5; figures 3; references 17: 10 Russian, 7 Western.

6900/9835
CSO: 1862/236

COHERENT PROPAGATION OF SMALL-AREA PULSES IN ACTIVATED CRYSTALS

[Article by O.P. Varnavskiy, V.V. Golovlev, A.N. Kirkin, R.F. Malikov, A.M. Mozharovskiy, M.G. Benedikt, and Ye.D. Trifonov, Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences]

[Abstract] Some of the features of coherent propagation of small-area pulses in inverted media are investigated. Induced superfluorescence in Nd:YAG and ruby is investigated analytically, indicating the possibility of observing that phenomenon in activated crystals with typical line widths. The amplification of picosecond pulses in Nd:YAG and ruby is investigated experimentally using 8x80 mm Nd:YAG rods with an Nd concentration of 0.6%. Lethargic amplification and induced superfluorescence were investigated, along with interference effects in the amplification of pulses with oscillating envelope. The findings make it possible to track the connection between coherent amplification of small-area pulses and superfluorescence pulse formation in an inverted medium. It is shown possible theoretically to obtain a self-similar pulse of induced superfluorescence by exciting the uniform polarization of the medium by a pulse with duration shorter than, or of the order, of the superfluorescence time. The modes investigated may turn out to be useful in a practical sense from the viewpoint of forming high-power ultrashort pulses. Figures 11; references 29: 9 Russian, 20 Western.

OPTICALLY INDUCED GENERATION OF SOUND IN PHOTOCONDUCTING PIEZOELECTRIC MATERIAL

[Article by V.N. Deyev and P.A. Pyatakov]

[Abstract] Generation of surface acoustic waves in photoconducting piezo-electric materials by means of nanosecond laser pulses with periodic intensity distribution over the surface is considered, an experiment having demonstrated the feasibility of attaining high efficiency of optoacoustic conversion in a high-resistivity CdS crystal. The apparatus for this experiment consisted of an LTI PCh-7 solid-state laser emitting pulses of τ = 20 ns duration at the λ = 0.53 μm wavelength, an interferometer forming a periodic surface distribution of laser power density, an optoacoustic cell, a synchronizing device, a generator of bias voltage pulses, and an oscillograph. The optoacoustic cell contained a 1.5 mm thick CdS plate 15 mm wide and 50 mm long, one long edge coinciding with the Z-axis and both faces perpendicular to the Y-axis.

Both faces were polished to an optical finish. On one of them were deposited two interdigital piezoelectric transducers, at opposite ends of the plate, their center frequency and bandwidth being $f_0 = 15.6$ MHz and $\Delta f = 1.5$ MHz respectively. Between them were deposited three 1 mm wide aluminum electrodes 1.5 mm apart at a 45° angle to the plate edges. This structure was placed on a metal substrate-electrode, with a thin glycerin interlayer under the smooth face of the plate. Simultaneous application of a bias voltage pulse to one aluminum electrode and of a laser pulse to the same side of the CdS plate produced an interference pattern in the form of a sinusoidal variable-intensity grating between two aluminum electrodes and a surface acoustic wave between the two transducers. The amplitude of a thus generated surface acoustic wave was found two depend on both the bias pulse voltage above the 15 V threshold and on the maximum laser power density above the 1.25 W/cm^2 threshold, namely to increase almost linearly with the bias pulse voltage and to peak at some intermediate maximum laser power density (300 W/cm^2 at 1200 V). An analysis of the data indicates that the efficiency of light-to-sound conversion by the same mechanism is two orders of magnitude higher in a CdS crystal than in a $Bi_2(SiO_3)_3$ crystal. The authors thank A.A. Chaban for helpful discussion. Figures 2; references 4: 3 Russian, 1 Western.

GENERATION OF SMALL-SCALE STRUCTURES OF THE SURFACE RELIEF OF SILICON AFTER PICOSECOND EXPOSURE

[Article by A.A. Bugayev, B.P. Zakharchena, and V.A. Lukoshkin, Physico-Technical Institute imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] The detection is described of small-scale structures on the surface of silicon, the generation of which was obtained during excitation by a laser pulse with a duration of 35 picoseconds and a wavelength of 1.06 micrometer. A YAG:Nd^{3+} generator was used, operating in mode locking. Figures 1; references 9: 6 Russian, 3 nonRussian.

RELAXATION OF ION-ELECTRON EMISSION IN Si AND Ge SINGLE CRYSTALS

[Article by V.V. Oznobishin and S.Ya. Lebedev, Institute of Power Engineering Physics, Obninsk]

[Abstract] An experimental study of ion-electron emission and its relaxation in Si and Ge single crystals upon their bombardment with ions was made, for the purpose of determining the dependence of its relaxation not only on the bombardment dose and the resulting change of surface profile but also on the initial bombardment time and especially on the subsequent change of bombardment angle. Plates of Si(111), Ge(313), Ge(337) single crystals as targets were bombarded with 70 keV Ar^+ ions while being rotated about their [110] axis perpendicular to the ion beam. The divergence of the ion beam did not exceed 0.5° and the residual pressure of gases above the target surface did not exceed $6 \cdot 10^{-5}$ Pa. Purity of the target surface was achieved by heating to 700°C under vacuum and then maintained by bombardment with an ion beam of high current density up to 1 mA/cm^2. The temperature of targets was measured with a Chromel-Alumel thermocouple accurately within 30-40°C and the integral ion-electron emission coefficient was measured by the collector method with an analog device accurately within 5%. The results confirm that relaxation of ion-electron emission is subject to a directional effect above a threshold target temperature, namely above the temperature at which radiative defects in the target are annealed, this temperature being different for different target material and ion combinations. Relaxation of ion-electron emission, manifested by a changing magnitude of the emission coefficient and evidently a result of transient process occurring in the crystal surface layer as the bombardment angle changes, was found to be a nonmonotonic process but with a definite length of stabilization time. Figures 4; references 14: 8 Russian, 6 Western.

SURFACE OPTICAL VIBRATIONS OF MOLECULAR CRYSTAL CONTIGUOUS TO A MEDIUM

[Article by S.Ya. Vetrov and V.F. Shabanov, Institute of Physics, Siberian Department, USSR Academy of Sciences, Krasnoyarsk]

[Abstract] Surface optical vibrations of a molecular crystal are analyzed on the basis of the simplest model describing a crystal lattice with one molecule per unit cell. Identical rigid linear molecules are assumed to be residing in the lattice nodes, their pinned centers of inertia coinciding with the inversion center of the crystal. Each molecule is assumed to interact only with its two nearest neighbors, an intermolecular bond possibly rupturing as a result. Analysis is based on the equation of rotational motion for a semiinfinitely large crystal lying on the surface of a medium and interacting with the latter dissipatively, in friction. Calculations lead to a cubic algebraic equation and a dispersion equation, their solution indicating an influence of the contiguous medium on surface optical vibrations of the crystal depending on the magnitude of the interaction parameter. The frequency decreases somewhat and the damping increases appreciably, while the penetration depth into the crystal decreases, with stronger interaction above a threshold level. References 9: 7 Russian, 2 Western (1 in Russian translation).

2415/9835
CSO: 1862/265

NATURE OF RECOMBINATION CENTERS IN p-Si BOMBARDED BY γ-QUANTA

[Article by L.S. Berman, V.B. Voronkov, M.L. Kozhukh, K.Sh. Kushashvili, and M.G. Tolstobrov, Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] The defect level after bombardment by fast electrons (1 MeV) or γ-quanta is definitely known to be much lower in p-Si than in n-Si, but available data on the nature of recombination centers in p-Si are contradictory and explanations given for the higher radiation resistance of p-Si differ widely. A recent study confirms the hypothesis based on two earlier studies that A-centers are the principal recombination centers in the base region of n^+-p and p^+-n silicon diodes, other centers such as oxygen complexes being much weaker recombination centers. In the experiment eight specimens of p-Si doped with boron (electrical resitivity ρ = 2 ohm·cm) were grown by the Czochralski method, with an n-region produced by diffusion of phosphorus.

The embedment depth of the p-n junction was 50 μm in four specimens and 10 μm in four specimens. The concentration of recombination centers was measured by the method of isothermal capacitance relaxation. The electron lifetime was measured at two current densities corresponding to a low injection level (0.5 A/cm^2) and a high injection level (10 A/cm^2) respectively. The readings were analogous for both groups of specimens, indicating recombination of minority charge carriers in the p-base principally. The concentration of residual deep centers was subsequently measured before and after bombardment by γ-quanta. A comparison with earlier results indicates that the rate of A-center and $V_2 + 0$ injection into p-Si and into n-Si is of the same order of magnitude, while K-centers are injected into p-Si at a rate one order of magnitude lower than into n-Si. The presence of boron ($8 \cdot 10^{15}$ cm^{-3}) evidently does not slow down injection of A-centers and $V_2 + 0$. The conclusion about A-centers was further verified by measurements after annealing at 150-175-200°C for 20 min at each temperature and the concentration of A-centers having decreased in the process, evidently to form $E_c - 0.37$ eV centers. Further annealing at 250-350°C removed A-centers completely, restoring both low-injection and high-injection electron lifetimes, while it increased the concentration of K-centers somewhat. This proves that A-centers are the principal recombination centers in the p-base region. Subsequent annealing at still higher temperatures removed K-centers, without changing the electron lifetimes. This proves that K-centers in p-Si are weak recombination centers. In three control specimens, p-Si grown by the floating-zone method (electrical resitivity o 20 ohm·cm) was neutron-doped into n-Si (electrical resistivity o 7 ohm·cm) and a p-region here was produced by diffusion of boron. The results of analogous measurements lead to the same conclusion. Figures 1; references 16: 11 Russian, 5 Western.

2415/9835
CSO: 1862/268

SELF-SUSTAINED OSCILLATIONS DURING PLASMA RESONANCE IN NARROW-BAND
SEMICONDUCTORS

[Article by P.N. Shiktorov, Institute of Semiconductor Physics, LiSSR
Academy of Sciences, Vilnyus]

[Abstract] Narrow-band semiconductors with a nonparabolic dispersion law
are considered, and the possibility of self-sustained oscillations of the
charge carrier concentration during stimulated plasma resonance is
demonstrated theoretically on the simple model of a thin plate in a micro-
wave electric field with the polarization vector normal to the plate
surface. Resonance occurs when the plasma frequency of free electrons
becomes equal to the frequency of that electric field. In an electric field
with an amplitude sufficiently large for impact ionization by electrons
within the region at resonance but not outside that region, the increase of

electron concentration within that region will raise the plasma frequency so as to knock it out of resonance with an attendant ionization cutoff. The subsequent reverse process of recombination will decrease the electron concentration and thus lower the plasma frequency so as to restore resonance. This oscillation can be self-sustained when the electron spectrum is non-parabolic. The equation for the electron momentum is solved by the method of slowly varying amplitude, first on the basis of E.O. Kane's parabolic dispersion law, which yields a resonance diagram for a system with increasing stiffness and a hysteresis region between two critical values of the momentum parameter. Accounting for the electron distribution in the momentum space and for fluctuations of this distribution, which characterize a multiparticle medium, does not remove the hysteresis. The mean electron energy in n-InSb at a temperature of 80 K during plasma resonance in an electric field of 140 GHz frequency and 900 V/cm amplitude was calculated on the basis of simulation of the electron ballistics by the multiparticle Monte Carlo method, using 1000 electrons, and solution of the current equation by the predictor-corrector method. The author thanks Ye.V. Starikov and A.Yu. Matulis for helpful discussions. Figures 2; references 5: 3 Russian, 2 Western (1 in Russian translation).

2415/9835
CSO: 1862/268

NONEQUILIBRIUM FLUCTUATIONS OF CHARGE CARRIER TEMPERATURES AND CONCENTRATION IN ZERO-GAP SEMICONDUCTORS

[Article by A.A. Tarasenko, P.M. Tomchuk, and A.A. Chumak, Institute of Physics, UkSSR Academy of Sciences, Kiev]

[Abstract] Nonequilibrium fluctuations of electron temperature and concentration in semiconductors with zero energy gap are analyzed, considering only fluctuations caused by electron-hole collisions and taking into account that every recombination event changes the temperature as well as the Fermi level of electrons. The recombination frequency is almost the same as the frequency of nonrecombining collisions in such a case, both energy and momentum transferred during electron-electron collisions being very small, but each kind of collision is associated with a different energy relaxation process and, moreover, concentration fluctuations are manifested in current fluctuations. The equations of temperature and concentration fluctuations are formulated accordingly, assuming an equilibrium hole distribution and a hole mass m_h much larger than the electron mass m_e so that the ratio of their respective characteristic energy relaxation frequencies is proportional to $(m_h/m_e)^{5/2}$. With the hole concentration not very low, moreover, holes are assumed to be the carriers of Joule-effect energy from the electrons to the lattice. Their temperature fluctuations are zero, therefore, but their distribution is still perturbed by their concentration fluctuations. Calculations reveal that there are two characteristic relaxation frequencies, the higher one

characterizing relaxation of the sum of referred electron Fermi level and hole Fermi level. The lower frequency and correspondingly longer period characterizes the electron energy relaxation. This relaxation period is found to determine the recombination time for nonequilibrium electron-hole pairs, except in the case of zero energy perturbation by both charge carriers. The correlation functions for Langevin fluctuation sources are determined for Coulomb electron-hole interaction, revealing that current fluctuations decrease with decreasing ratio of hole concentration to electron concentration. An evaluation of both characteristic relaxation frequencies for a semiconductor such as HgTe at low temperature (T = 4 K), at which electron-hole collisions are significant, yields such a tremendous difference between them as to indicate a two-stage recombination process. References 8: 6 Russian, 2 Western.

2415/9835
CSO: 1862/268

VELOCITY OF ULTRASOUND IN MELTS OF SEMICONDUCTING SILVER CHALCOGENIDES

[Article by V.M. Glazov, A.S. Burkhanov, and K.B. Nurov, Moscow Institute of Electronic Engineering]

[Abstract] The velocity of ultrasound in semiconductors of the Ag_2S, Ag_2Se, Ag_2Te group was measured, for a determination of structural changes occurring within a wide temperature range about the melting point and for thus explaining the anomalous temperature dependence of the diffusion coefficient characterizing the behavior of Ag ions. Test specimens were prepared from 99.9994% pure Ag, 99.999% pure Se, and twice vacuum distilled TA-1 tellurium. Precise amounts of each element were heated in stages at a rate of 2-4 K/min, with intermediate holding of Ag, Se, Te for 1 h at the respective melting point and of S at its melting point for 6 h so as to prevent excessive buildup of its vapor pressure. They were mixed in a quartz tube under a vacuum of 10^{-2} Pa, for synthesis in the liquid phase at temperatures 50-100 K above the melting points. A special technique was used for avoiding precipitation of a second phase, namely pure silver, in the entire process. Cooling was also done in two stages, with intermediate holding for 1.5-2 h at a temperature 30-50 K below the melting point of the compound before quenching in aqueous 10% NaCl solution. The ultrasonic measurements performed by the pulse method at a carrier frequency of 5 MHz, in an atmosphere of high-purity Ar, were accurate within 0.2%. The acoustic velocity was measured over the temperature ranges of 1150-1240 K in Ag_2S, 1210-1300 K in Ag_2Se, 1280-1380 K in Ag_2Te, with the statistical variance at each temperature not exceeding ±2 m/s. The trend of the acoustic velocity v_s with rising temperature T was found to be analogous in all three compounds, namely a steep decrease immediately after melting followed by a narrow plateau over a 10-12 K temperature range and another but not so steep decrease. While the experimental data fit closely the linear equation $v_s = a - bT$ in the high-temperature

range, with the values of parameters a,b different for each compound and calculated by the method least squares, they slightly oscillate in the low-temperature range. The temperature dependence of the adiabatic compressibility β_s was calculated from the temperature dependence of the acoustic velocity in accordance with the Laplace equation $v_s^2 = (\beta_s \rho)^{-1}$ expressing an inverse-square law with density ρ of the material as coefficient. The anomalies of v_s and β_s correlate with the anomalous diffusion of Ag ions characterized by a dipping of the diffusion coefficient to a minimum within a narrow temperature range peculiar to each compound. Figures 3; tables 1; references 18: all Russian.

2415/9835
CSO: 1862/268

QUANTUM EFFECTS DURING ELECTRON-ELECTRON INTERACTION IN DOPED $A^{III}B^V$ CRYSTALS

[Article by T.I. Voronina, O.V. Yemelyanenko, T.S. Lagunova, and D.D. Nedeoglo, Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] All four corrections adding up to the total change in electrical conductivity of metallically behaving doped $A^{III}B^V$ crystals (n-GaAs, n-InAs, n-InP) in a magnetic field have been established independently by measurements at temperatures of 1.7-4.2-10 K over the 0.3-10 Oe range of magnetic field intensity. These corrections are for the localization effect caused by "noninteracting" electrons, the Maki-Thompson correction for scattering by superconductive fluctuations during pure Coulomb repulsion, the Aronov-Al'tushuler correction for change in density of states cuased by electron-electron interaction, and the Lee-Ramakrishnan correction for spin interaction. Measurements were made on specimens with widely ranging T (2-300) and $k_F l$ (0.4-4). A comparison with theoretical calculations, taking into account diffusion and the g-factor as well as proximity to the metal-dielectric transition, indicates an exact or very close agreement. Figures 2; references 6: 3 Russian, 3 Western.

2415/9835
CSO: 1862/268

18

GENERATION OF ULTRASHORT DEFORMATION PULSES IN SEMICONDUCTORS UPON
ABSORPTION OF LIGHT

[Article by S.M. Avanesyan and V.E. Gusev, Department of Physics, Moscow
State University imeni M.V. Lomonosov]

[Abstract] Generation of ultrashort acoustic (deformation) pulses in a
semiconductor at room temperature upon absorption of picosecond light pulses
is analyzed with consideration of three contributing factors. One factor is
the strong dependence of the optical absorption coefficient on the photon
energy excess over the energy gap of the semiconductor material, which allows
varying the characteristic depth of the photoexcitation region over a wide
range by use of a tunable light source. Another factor is the slow diffusion
of excess photo-excited charge carriers. Most important is crystal lattice
deformation not by the thermoeleastic mechanism alone but also by another
mechanism, namely the "electronic" mechanism. The theoretical model describ-
ing the process of optical excitation of such an acoustic generator is based
on a one-dimensional wave equation for the vibration velocity of a longitudin-
ally propagating sound. This equation is solved for generation of hypersound
in a solid semiconductor following absorption of light near the surface.
According to calculations and available experimental data pertaining to
silicon, there are two possible modes of generating picosecond hypersound
pulses by means of picosecond light pulses. The acoustic rarefaction pulse
first and compression pulse next can be made ultrashort when using low-
intensity light with a photon energy excess sufficient, however, to ensure
that the optical absorption coefficient dependent on the photon energy be
not smaller than the inverse of the light pulse duration times the speed
of light, by making both the depth of the photoexcitation region equal to
the inverse of the optical absorption coefficient and the diffusion length
as small as necessary. The compression pulse but not necessarily the
rarefaction pulse can be made ultrashort when using high-intensity light,
by ensuring that the charge-carrier recombination time be shorter than the
light pulse duration. An analysis of each mode of excitation reveals how
the duration of generated hypersound pulses in each case depends on the
charge-carrier diffusion time and recombination time as well as on the sound
transit time through the photoexcitation region. The authors thank
S.A. Akhmanov, and N.I. Zheludev for helpful discussions. References 31:
9 Russian, 22 Western (2 in Russian translation).

ACOUSTIC EMISSION IN METALLIC GLASSES

[Article by A.M. Leksovskiy, A.Yu. Vinogradov, and V.V. Smirnov, Institute
of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] A study of acoustic emission in metallic glasses was made, for
the purpose of determining their strength and margin of plasticity. Specimens
of cobalt glasses $Co_{74}Fe_6B_{20}$, $Co_{70}Fe_5Si_{15}B_{10}$ and iron glasses $Fe_{72}Cr_8P_{14}C_6$,
$Fe_{40}Ni_{38}Mo_4B_{18}$ were produced by quenching from the liquid phase into 100 mm
long ribbons 2-10 mm wide and 0.02-0.04 mm thick. They were tested in tension
at room temperature, with the strain rate varied over the $2.1 \cdot 10^{-5} - 4.2 \cdot 10^{-4}$
s^{-1} range. Acoustic emission signals were picked up by piezoceramic transducers
with a natural frequency of approximately 400 kHz, for recording by two
linear sound ranging and detection systems: one with an M-6000 computer and
one more elaborate with a Hewlett Packard minicomputer. The results revealed
an extremely nonuniform buildup of acoustic emission with increasing deforma-
tion along the specimens of each alloy, characterized by sporadic anomalously
large signal amplitudes. The dependence of the acoustic emission power on
the strain level and its distribution over a specimen indicate that those
large signals appear during various stages of deformation, according to a
different pattern in each material. In the weakest spot of a specimen acoustic
emission was found to temporarily cease, evidently after shear bands have
completely formed and microplasticization has become inhibited, prior to
fracture with attendant emission of a very strong signal. The acoustic
emission power at any strain level was found to increase with increasing
strain rate at which that level had been reached. Figures 2;
references 4; all Russian.

2415/9835
CSO: 1862/253

MECHANISM OF REVERSIBLE PICOSECOND BLEACHING OF STRAIGHT-BAND
SEMICONDUCTOR DURING INTER-BAND ABSORPTION OF HIGH-POWER LIGHT PULSES

[Article by I.L. Bronevoy, S.Ye. Kumekov, and V.I. Perel, Physical-
Technical Institute imeni A.F. Ioffe, USSR Academy of Sciences]

[Abstract] A previous experiment by the authors investigated the change in
transparency of thin epitaxial layers of GaAs irradiated by a light pulse
approximately 30 psec long. A change in transparency during the pulse
that was approximately reversible was detected, and the transparency
following the pulse was found to be independent of the pulse energy. The

change in transparency was far greater than would be expected if the only cause were a change in the spectrum of the quasiparticles. The present study explains those findings assuming that the dominant cause for reversible bleaching of the specimen is the generation of carriers on the leading edge and light-induced recombination on the trailing edge of the pulse due to intra-band heating by the exciting light. Figures 2; references 10: 6 Russian, 4 Western.

LASERS

EMISSION OF RADIATION AT DIFFERENCE FREQUENCY FROM LASER IN RECTANGULAR
WAVEGUIDE PARTIALLY OCCUPIED BY NONLINEAR CRYSTAL

[Article by Yu.O. Avetisyan and D.A. Bagdasaryan, Yerevan State University]

[Abstract] A laser in a waveguide with a nonlinear crystal is considered,
and emission of radiation at difference frequency is examined for the case
of a rectangular waveguide with such a crystal occupying only a part of its
cross-section. Field calculations are made for a waveguide of width 2a
and height b < 2a with a rectangular crystal of width 2d < 2a and also
height b symmetrically at the center of the waveguide cross-section. The
dielectric permittivity of the crystal material is ε_2, that of the other
waveguide medium on both sides is ε_1. As a doublet of two laser beams with
frequencies ω_1 and ω_2 propagates through the waveguide, interaction in the
crystal produces a polarization wave at difference frequency $\omega_1 - \omega_2$ and
thus radiation at that frequency. The field equation for the waveguide is
formulated, assuming vertical oscillations and a uniform amplitude through-
out the crystal. The corresponding homogeneous equation is solved for odd-
number transverse horizontal modes, assuming that no even-number modes are
excited. The result indicates that the degree of mode locking depends on the
ratio of crystal width to waveguide width. Some loss of efficiency owing to
particle rather than full waveguide occupancy by the crystal can be compen-
sated by concentrating all laser radiation the crystal. The analysis can be
extended to the case of a uniaxial crystal with any symmetric orientation in
the waveguide and to a nonlinear-polarization wave nonuniform over the
cross-section. Figures 1; references 10: 6 Russian, 4 Western (1 in
Russian translation).

UDC 539.182

INDUCED CHANGE OF POLARIZATION OF COHERENT ULTRASHORT LIGHT PULSE IN RESONANT
MEDIUM

[Article by A.Zh. Muradyan and A.S. Petrosyan, Scientific Research
Institute of Physics of Condensed Media, Yerevan State University]

[Abstract] Transient change of polarization of coherent ultrashort light
pulses under conditions of resonance is examined, for possible application
to spectroscopy of fast processes. As resonant medium is selected vapor of
an alkali metal, in which a weak probing light pulse resonantly couples the
ground state $nS_{1/2}$ of an atom to its first excited state $nP_{1/2}$ and a strong
circularly polarized light pulse couples that $nP_{1/2}$ state to a higher
excited state $n'S_{1/2}$. Deviation of the strong pulse from resonance is
assumed to be wider than its spectrum. Passage of a weak probing pulse
through the medium is characterized by transient behavior even without a
strong coherent ultrashort light pulse present, and the medium becomes
optically anisotropic owing to a Stark shift of magnetic half-levels in the
field of a strong coherent ultrashort light pulse. Simultaneous solution of
Schrödinger and Maxwell equations for this sytem, which has been done by
numerical methods, shows that linear polarization of an entering probing
pulse becomes in the medium elliptical with continuously varying parameters
and that such an elliptical polarization can degenerate into a circular
one. The principal axes of the polarization ellipse rotate relative to the
axes of the Cartesian laboratory system of coordinates, the angle of rotation
depending on the pumping energy and on the deviation of the strong light pulse
from resonance. In the case of small Nz (N- atom concentration, z- distance
traveled by both coherent ultrashort light pulses) elliptical polarization
is negligible and the plane of linear polarization of a weak probing light
pulse simply rotates. In the case of small nonlinearity transient interaction
does not occur and change of polarization approaches steady-state conditions.
Figures 2; references 14: 7 Russian, 7 Western (1 in Russian translation).

EXCIMER LASER PUMPED BY RELATIVISTIC HIGH-CURRENT MICROWAVE OSCILLATOR

[Article by A.N. Didenko, V.M. Petrov, V.N. Slin'ko, A.S. Sulakshin, and
S.S. Sulakshin, Scientific Research Institute of Nuclear Physics, Tomsk
Polytechnic Institute imeni S.M. Kirov]

[Abstract] For the first time a XeCl excimer laser was excited by a micro-
wave pulse from a relativistic magnetron. In the experiment such a magnetron
with sputter-emission cathode was energized by a TONUS high-current electron
accelerator, with a cathode voltage of 900 kV for a duration of $\tau_{0.5}$ = 50 ns
and with a magnetic field of 4.5 kG produced by a pair of Helmholtz coils.
The microwave pulse of $\tau_{0.5}$ = 30 ns duration and with a power of 320 MW
was guided into a 110 cm long quartz gas-discharge tube with a 10 cm inside
diameter. The optical resonator, 120 cm long, was formed by an opaque plane
aluminum mirror and a plane-parallel quartz plate. As active medium were
used high-purity He, Ne, Xe and chemically pure CCl_4, under a pressure which
could be varied up to 13 atm. Maximum efficiency of $0.47\pm0.14\%$ was obtained
with a $He(Ne):Xe:CCl_4$ = 95:18:1 mixture under a pressure of 1.5 atm and with
a pumping density of 100 kW/cm^3. Figures 2; references 8: 7 Russian,
1 Western.

AMPLITUDE FLUCTUATIONS OF CONTINUOUS-WAVE YAG:Nd^{3+} LASER WITH PUMPING BY
LIGHT-EMITTING DIODES

[Article by A.A. Mak, V.I. Ustyugov, M.M. Khaleyev, A.L. Zakgeym, and
V.M. Marakhonov]

[Abstract] A study was made concerning the use of semiconductor radiation
sources such as light-emitting diodes for pumping solid-state lasers. In
the experiment a YAG:Nd^{3+} laser (wavelength λ_e = 1.06 µm) was pumped by multi-
mesa heterostructure AlGaAs light-emitting diodes (wavelength λ_p = 805$\pm$20 nm).
For establishing the stabilization level attainable by passive means, the
diodes were supplied from a storage battery. Drawing a power of 80 W at a
current of 0.8 A, they delivered to the immersion medium a total pumping
radiation power of approximately 10 W for a laser emission power of 80 mW.
Measurement and analysis of the laser amplitude fluctuation spectrum reveal a
record high emission stability attainable by down to 0.02% suppression of
low-frequency (2 Hz - 10 kHz) fluctuations and down to 0.13% suppression of
high-frequency (10-50 kHz) fluctuations, the r.m.s. percentage modulation
serving as measure of amplitude fluctuations, without resorting to automatic

control. An automatic control system for further suppression of up to
100 kHz fluctuations has been found to be feasible with a linear array of
light-emitting diodes as control element in the appropriate feedback loop,
fluctuations of laser emission near the frequency of relaxation oscillations
thus being reducible to below their natural level. The authors thank
O.A. Orlov and V.M. Volynkin for assisting in constructing the laser and
performing the experiment. Figures 3; references 9: 7 Russian, 2 Western.

SIMPLE INSTRUMENT FOR MEASURING NARROW EMISSION LINES OF SINGLE-FREQUENCY
LASERS

[Article by M.I. Belovolov, Ye.M. Dianov, A.V. Kuznetsov, V.Kh. Pencheva,
V.A. Sychugov, and T.V. Tulaykova, Institute of General Physics, USSR
Academy of Sciences, Moscow]

[Abstract] A simple instrument for measuring narrow laser emission lines
with 10 kHz - 1 MHz wide Lorentz contours has been built, using a Michelson
interferometer on single-mode fiber optics with a new scheme for recording
the luminosity of interference fringes. This interferometer consists of
one directional Y-coupler with arms of different lengths, a rotating mirror,
a silicon avalanche photodiode (avalanche multiplication factor 400, load
resistance 30 kohm) preceded by a diaphragm with a 100 μm wide and 5 mm
high slit for better sensitivity, a d.c. amplifier, and an oscillograph
with memory. The experimental equipment for developing and testing this
interferometer included a confocal scanning interferometer as control
device. As a source of strongly coherent light for the experiment was used
a tunable AlGaAs semiconductor laser with an external resonator, the latter
formed by a microobjective with 0.8 numerical aperture and a high-Q holo-
graphic total-internal-reflection selector with 3200 lines/mm. The width
of the emission line was measured with both interferometers. The degree
of coherence of light decreases with increasing width of the spectral line
and with increasing length difference between the coupler arms, this
difference having been varied in the experiment over the 0.1-10 km range.
Figures 2; tables 1; references 6: 1 Russian, 5 Western (1 in Russian
translation).

FORMATION OF SUBPICOSECOND PULSES WITH HIGH REPETITION RATE IN FIBER-OPTIC PULSE COMPRESSOR

[Article by V.A. Vysloukh, D.N. Dovchenko, N.I. Zheludev, V.I. Kuznetsov, L.Kh. Muradyan, and A.V. Simonov, Moscow State University imeni M.V. Lomonosov]

[Abstract] A theory has been developed and an experiment has been performed toward realization of a source of stable subpicosecond and femtosecond light pulses at the $\lambda = 0.532$ μm wavelength. It consists of a YAG:Nd^{3+} laser with Q-switching and mode locking, in a second-harmonic generator, and a single-mode fiber-optic pulse compressor. Self-propagation and phase self-modulation of radiation pulses in a fiber-optic lightguide are described by the nonlinear Schrödinger equation, with distance normalized to dispersion length and time normalized to initial pulse duration. Pulses of partially coherent radiation are considered, their behavior having been analyzed statistically by the appropriate Monte Carlo method. The experiment was performed using a continuously pumped YAG:Nd^{3+} laser with acoustooptic Q-switching and mode locking, an 8x4x5 mm^3 large KTP (KTiOPO$_4$) crystal between two lenses of a telescope for frequency doubling, a filter for 100% stopping the 1.064 μm radiation, a 10 m long fiber with a quartz core 7 μm in diameter between two microobjectives, and a holographic difraction grating as compressor. Duration and spectral width of compressed pulses were measured by the method of synchronous detection, with a noncollinear second-harmonic generator using an 800 μm thick KDP (KH$_2$PO$_4$) crystal. The pulse duration was found to depend on the length of the dispersive delay line, with a sharp dip to a minimum below 1 ps at a dispersion length of approximately 1 m. The width of the pulse spectrum was found to increase with increasing transmitted radiation power, first slightly and then steeply to a maximum. The authors thank M.S. Soskin, for supplying the holographic diffraction grating and I.I. Ashmarin for advice on use of the single-mode quartz fiber. Figures 4; references 9: 5 Russian, 4 Western.

PICOSECOND RADIATION SOURCES USING CONTINUOUSLY PUMPED GARNET LASERS

[Article by G.I. Onishchukov, M.F. Stel'makh, and A.A. Fomichev, Moscow Institute of Engineering Physics]

[Abstract] A new series of ultrashort-pulse light sources has been developed on the basis of a continuously pumped YAG:Nd^{3+} laser ($\lambda = 1.064$ µm wavelength) with simultaneous Q-switching and mode locking, with wavelength tuning and with pulse repetition rates of 1-10 kHz. Such a laser can generate pulses of 35-500 ps duration and 1 MW peak power at repetition rates up to 50 kHz after free emission. Frequency conversion is effected by operating this laser with extracavity or intracavity second-harmonic generation, without or including "pulse cutoff", using nonlinear optics ($\lambda = 532$ nm). Another method of frequency conversion is by synchronous pumping of a dye laser (rhodamine 6G: $\lambda = 555-640$ nm wavelength, pulses of 7-100 ps duration and 10 kW peak power) or a color-center solid-state laser (LiF:F$_2^+$: $\lambda = 850 - 1090$ nm, pulses of 30-500 ps duration and 10 kW peak power). It also appears to be feasible to further compress ultrashort pulses of a parametric light source to 200-300 fs duration at 1.55-1.65 µm wavelength, in a quasi-soliton mode of propagation through a single-mode fiber-optic waveguide within the negative-dispersion range ($\lambda > 1.3$ µm), by pumping such a parametric light source (Ba$_2$NaNb$_5$O$_{15}$)crystal: $\lambda = 755-1800$ nm wavelength, pulses of 5-100 ps duration and 10 kW peak power) with a YAG:Nd^{3+} laser in the second-harmonic generation mode. The authors thank P.G. Konvisar, V.V. Novikov, and S.D. Ryabko for assistance in performing a series of experiments. Figures 3; tables 1; references 6: all Russian.

LASER METHODS OF MEASURING STATISTICAL CHARACTERISTICS OF SEA SURFACE

[Article by K.I. Volyak, V.G. Mikhalevich, T.B. Shevchenko, and I.V. Shugan, Institute of General Physics, USSR Academy of Sciences]

[Abstract] Laser probing of the sea surface from an airplane or satellite offers the advantages of a much higher resolution than that of a microwave radar and of not requiring uniform natural illumination as does aerial photography. The two basic methods of laser probing now employed are pulse radar and phase profilometry. The first method involves measurement of the time lapse from departure of probing pulses to arrival of reflected pulses and waveform analysis of the latter. In the second method a range finding laser is used for measurement of altitudes. A laser on board of an airplane can also be used for measuring from a far distance the statistical characteristics of sea surface ripples or waves, by continuous probing of that surface and recording of the return signal. The latter constitutes a random sequence of optical pulses corresponding to incidence of the probing light beam on surface elements at almost a mirror angle. Statistical analysis of a random sparkle surface, based on a "quasi-specular" model, yields much information about the energy spectrum and the correlation function of a two-dimensional random surface. Implementation of this method is demonstrated on a model experiment with an airplane flying horizontally above the sea surface while sending a narrow laser beam vertically down so that the latter thus sweeps generally oblique surface elements. Such a ripple surface intersects the quiescent free "horizontal" sea surface along a random curve, principal object of probing. The mean number of sparkles per unit length of these curves and the dispersion of that number provide essential sought statistical characteristics of the sea surface. The principle of this method can be extended to oblique probing. It can also be extended to "far field" probing, with adjustment for departure from "quasi-specularity", so that eventually laser probing will yield much more complete data and preliminary modeling will become unnecessary. Figures 1; references 11: 4 Russian, 7 Western.

2415/9835
CSO: 1862/262

GREEN HgCl-LASER WITH WIDEBAND OPTICAL PUMPING

[Article by S.P. Bazhulin, N.G. Basov, S.N. Bugrimov, V.S. Zuyev,
A.S. Kamrukov, G.N. Kashnikov, N.P. Kozlov, P.A. Ovchinnikov, A.G. Opekan,
V.K. Orlov, and Yu.S. Protasov, Institute of Physics imeni P.N. Lebedev,
USSR Academy of Sciences, Moscow, and Moscow Higher Technical School
imeni N.E. Bauman]

[Abstract] An experimental study of a $HgCl_2$-vapor photodissociation laser
with optical pumping was made, using an open high-current surface discharge
with a linearly stabilized spark channel as excitation source. Inside the
laser tube made of stainless steel, 14 cm in diameter and 110 cm long,
was placed a 50 cm long teflon plate 4 cm wide and 6 cm thick separating two
molybdenum electrodes. The tube contained $HgCl_2$ vapor with a partial pressure
not exceeding 1 mmHg and a N_2:Ar = 15:1 buffer gas mixture with a partial
pressure of 2.5 atm. The active medium, $HgCl_2$ vapor, was produced from $HgCl_2$
powder in a separately heated separate evaporator and admitted to the laser
tube through a high-vacuum high-temperature check valve. The evaporator
temperature was held within 230±10°C, corresponding to a vapor saturation
pressure of 50-100 mmHg. The laser tube, with nonadjustable quartz windows
at both ends for extraction of laser radiation, and the external plane-
parallel resonator with a 0.3 overall transmission coefficient for wavelengths
within the 530±10 nm band were placed in a thermostat and heated to 250°C.
Electric discharge was initiated by pulses through auxiliary electrodes 1 mm
in diameter built into the teflon plate 10 mm apart between the main
electrodes, which facilitated buildup of a stable breakdown wave in a weak
electric field with E/p not exceeding 0.5 kV/(cm·atm) and space stabilization
of the spark-streamer channel for formation of a precisely straight plasma
filament. The pulse energy from an IK-50-3 capacitor bank was varied over
the 0.95-3 kJ range at fixed 25 kV. The discharge was optimized at the
0.95 kJ level, an almost aperiodic discharge current pulse of 16 kA amplitude
and 7.5 μs duration causing plasma expansion at a rate of approximately
1.5 km/s. Pumping with a wide band of vacuum-ultraviolet radiation resulted
in photodissocation into HCl radicals with a B→X electron transition and
attendant emission of green light at two wavelengths: 558 nm and 559 nm.
Pulses of up to 2.1 J energy (7.6 J/dm^3), attainable with an active medium
having an absorption coefficient of 1.2 m^{-1}, and up to 7.6 μs duration were
generated by this HCl-laser with a repetition rate of approximately 0.1 Hz
and an overall efficiency of 0.1%. The authors thank Yu.Yu. Stoylov for help-
ful discussion of the results and V.V. Pochtarev for assistance in the laser
experiments. Figures 3; references 17: 6 Russian, 11 Western.

SPECTRAL CHARACTERISTICS OF GLASS-FIBER NEODYMIUM LASER

[Article by M.I. Dzhibladze, S.K. Isayev, Z.G. Melikishvili, and
Z.G. Esiashvili, Tbilisi State University]

[Abstract] An experimental study of a glass-fiber neodymium laser was made,
for a determination of its spectral characteristics over the 100-600 k
temperature range. After activation of 1.5 m long fibers of silicate glass
with neodymium, making the refractive index of the 40 μm diameter core and of
the 8-10 μm thick sheath 1.54 and 1.52 respectively, their emission spectra
were measured with an MDR-3 monochromator with 1 cm^{-1} resolution. The spectra
were found to consist of discrete lines not more than 1 cm^{-1} wide, only one
0.5 cm^{-1} wide line or sometimes 2-3 such lines at the threshold, their number
increasing with higher pumping energy. The width of the spectrum also
increased, but only to saturation, as teh ratio of pumping energy to threshold
level increased. The width of the spectrum at any pumping level decreased as
the temperature of the active medium increased, narrowing first fast as the
temperature rose to 350 K and then much slower as the temperature rose higher.
These trends, similar in free emission and in emission of giant pulses, are
explained by a mode analysis. Figures 3; references 6: 5 Russian,
1 Western.

2415/9835
CSO: 1862/240

CHARACTERISTICS OF METAL IGNITION IN AIR BY RADIATION FROM CONTINUOUS-WAVE
LASER

[Article by F.V. Bubkin, N.A. Kirichenko, B.S. Lukyanchuk, Ye.A. Morozova,
Yu.Yu. Morozov, and A.V. Simakin, Institute of General Physics, USSR
Academy of Sciences, Moscow]

[Abstract] Ignition of metals in air by radiation from a continuous-wave
laser is analyzed theoretically on the basis of a thermodynamic model of
metal oxidation. The general equation of the temperature transient is
formulated for a metal plate in air, assuming a thin disk of infinitely
large radius with a building up oxide surafec film. Included are thermal
conductivity and thermal diffusivity of the metal, absorptivity of the oxide

film dependent on its thickness, and the radial intensity profile of incident radiation, also the heat of combustion. During initial heating the absorptivity of the oxide film increases as a parabolic function of the film thickness. In the ideal case it subsequently remains constant. The stability limit or ignition threshold then corresponds to a balance reached between heat conduction and heat releases during exothermic oxidation, when the laser radiation intensity reaches a threshold level equal to some function of the laser beam radius and ignition begins at the center before the flame will spread radially outward. This stability limit is calculated assuming, for simplicity, that the oxide film thickness increases as a linear rather than parabolic function of time. In the real case oxidation activation by laser radiation results in a sharply peaking temperature profile and in a variable absorptivity of the oxide film, changing faster under the hot spot than elsewhere. The stability limit then becomes a bifurcating one, determined by the generally nonmonotonic change of absorptivity as well as the heat release during exothermic oxidation and possibly other factors such as nonlinear heat losses, surface shielding, oxide evaporation, and departure from the established law of oxidation kinetics caused by large temperature gradients. An experiment was peformed with titanium, a 0.5 mm thick and 8x10 cm^2 large plate, using an LTN-101 continuous-wave YAG laser (λ = 1.06 μm wavelength) and a focusing lens with a focal length of 8 cm. The radiation power was measured with an IMO-2N calorimeter behind a focusing lens through which a part of the laser beam had been diverted to it by a beam-splitting glass plate. For measuring the dimensions of the laser spot on the surface, another part of the radiation was diverted by means of a beam-splitting wedge to an FD-24K photodiode through a perforated vane with 35 holes 0.3 mm in diameter forming a spiral so as to cover a laser beam 10.5 mm in diameter with the origin of the spiral 80 cm away from the vane shaft. The position of the titanium plate was monitored with an LG-52-3 gas laser. Radiation from titanium was recorded by two FD-24K photodiodes on the front side and on the back side respectively. The results indicate that the ignition threshold for titanium under radiation of a continuous-wave YAG laser is an intricate nonmonotonic function of laser radiation parameters, generally confirming the theoretical conclusions, with a nontrivial size effect in the ignition dynamics and with an oscillatory combustion front in the case of a small laser spot on the surface. Figures 6; references 11: all Russian.

EMISSION OF ULTRASHORT PULSES WITH DURATION CONTROL BY YAG:Nd^{3+}-LASER WITH PASSIVE MODE LOCKING

[Article by V.I. Bezrodnyy, Ye.A. Tikhonov, and N.Ya. Nedbayev, Institute
of Physics, UkSSR Academy of Sciences, Kiev]

[Abstract] Duration control of ultrashort laser emission pulses by means of
a saturable nonlinear absorber-filter is analyzed, this relatively simple
method being applicable to solid-state lasers such as a YAG:Nd^{3+} with
passive mode locking. Following free emission without absorption saturation
(first threshold), the ultrashort pulses pass through a linear amplifier
with attendant narrowing of its spectrum and then, amplified, through a
nonlinear filter (second threshold) with attendant amplitude discrimination
and time compression owing to saturation followed by gain saturation with
formation of the pulse sequence envelope. This process is described by a
mathematical model for pulses with a Gaussian profile, assuming a shutter
with the activator relaxation time much shorter than the emission pulse
duration and a laser optics configuration equivalent to that of a traveling-
wave ring resonator. On this basis are derived expressions for the time
compression factor in passage through the nonlinear absorber-filter and
the time expansion factor in passage through the linear amplifier. In the
experiment with a GP 5x60 YAG:Nd^{3+} laser cell and a 1 m long resonator
formed by two plane mirrors with reflection coefficients $R_1 \approx 1.0$ and $R_2 \approx 0.70$
respectively, the passive Q-switch made of polyurethane acrylate was
activated by 4363 dye of high optical strength and with a 5-7 ps relaxation
time. Pulse duration was measured with an "Agat-SF" photochronograph and,
for monitoring the reproducibility, also with an S-7-10 B oscillograph
using an FEK-19 KM coaxial photocell. Pulse energy was measured with an
IMO-2M calorimeter. Measurements were made with the transmission coefficient
of the absorber-filter varied, the pulse discrimination failing with T_0
higher than 0.8 but the duration of single pulses being almost 100% reproducible
with T_0 within the 0.33-0.75 range. The results indicate the feasibility
of regulating the duration of laser emission pulses by this method over
the 15-100 ps range. The excellent reproducibility, related to but not
identical with stability of pulse energy and duration, is attributed to
self-locking of free-emission modes in a YAG:Nd^{3+} laser. Figures 4;
tables 1; references 14: 6 Russian, 8 Western.

MECHANISM OF INVERSION QUENCHING IN XeCl-LASERS EXCITED BY ELECTRON BEAMS

[Article by I.M. Isakov, A.G. Leonov, V.I. Nevmerzhitskiy, I.V. Novobrantsev, and V.R. Solovyev, Moscow Institute of Engineering Physics]

[Abstract] It has been demonstrated experimentally that differences in shape and amplitude of XeCl-laser emission and amplification pulses depending on the composition of the gas mixture are determined by three kinetic factors: 1. accumulation of atomic chlorine and attendant population of the lower laser level, 2. resonance quenching of only vibrationally excited $v > 3$ XeCl(B) molecules by HCl molecules, 3. different roles played by heteronuclear molecular RXe^+ ions, depending on the kind of buffer gas ($R = Ar$ or Ne), in formation of the charge content in the plasma. These heretofore ignored factors explain several heretofore unexplained phenomena such as quenching of laser emission when luminescence from the upper laser level is near maximum, switch from amplification to attenuation in the active medium at the laser wavelength prior to the end of pumping action while luminescence continues after pumping, and decrease of the peak emission power with increasing HCl pressure above 1 torr. The experiment was performed with an XeCl-laser excited by an electron pulse beam of 10^{-6} duration and 20 A/cm^2 current density. The experimental data together with calculations of the plasma content and of the emission intensity at the B–X transition in Ar-Xe-HCl and Ne-Xe-HCl mixtures indicate that quenching of emission prior to the end of the excitation pulse is caused by depletion of the halogen carrier and formation of XeCl(X) according to the reaction $Xe + Cl + Ar \rightleftarrows XeCl(X) + Ar$. Addition of an agent which reacts with Cl without quenching the XeCl(B) state should prevent this and prolong the effectiveness of a XeCl-laser. Figures 2; references 7: 1 Russian, 6 Western.

POSSIBILITIES FOR PLASMA FILTER CONTROL OF COHERENT PROPERTIES OF HIGH
POWER LASER BEAMS

[Article by V.V. Aleksandrov, M.V. Brenner, S.V. Loburev, N.G. Kovalskiy and
A.M. Rubenchik, Institute of Atomic Energy imeni I.V. Kurchatov, Moscow]

[Abstract] A light flux density of 10^{12} to 10^{14} W/cm^2 was produced at the
surface of a variety of solid targets by the "Mishen 1" neodymium laser
facility. The spatial structure of the radiation scattered by the nonuniform
plasma corona was photographed in the near field in order to ascertain the
spectral, coherency, angular and energy parameters of the radiation when
polyethylene, aluminum and lead targets were used. A high degree of
uniformity is observed in the beam produced by the scattered radiation
because of coherency losses at the reflecting surface which takes on a
"ripple" structure. This reduction in the spatial coherency of the scattered
beam, characteristic of both light and heavy targets, opens up the possibility
of controlling the beam coherency and developing high power laser beams
with small coherency volumes suitable for the irradiation of spherical
thermonuclear targets. The radiation uniformity requirement (minimal
permissible spectral width) under conditions characteristic of solid state
lasers used for fusion initiation is estimated at 3 nm or more with the
laser beam having $2.5 \cdot 10^3$ modes. If the observed coherency loss is due
to stochastic rippling, then the structure of the critical surface in the
plasma corona can be determined from the measured coherency and spectrum
of the mirror reflected radiation. Since the development of a ripple
structure at the reflecting surface exhibits threshold behavior, the
coherency loss that produces uniform intensity distribution in the reflected
beam is increased with an increase in the light flux density impinging on the
plasma filter. Photographs of the laser beam in the near field with and
without the plasma filter are shown along with a detailed block diagram
of the "Mishen 1". Figures 6; references 12: 4 Russian, 8 Western.

SPECIFIC FEATURES OF SIGNAL PULSE GENERATION IN SHORT HIGH POWER PUMPING PULSE FIELD WITH DOUBLE RESONANCE IN COMMON UPPER LEVEL SCHEME

[Article by A.Ye. Dmitriyev and O.M. Parshkov, Saratov Polytechnical Institute]

[Abstract] A rarefied gas lasing medium is modeled by an ensemble of three level quantum systems with simple levels numbered in order of increasing energy as 1, 2, 3. Prior to the pumping pulse input, only level 1 is populated. Partial differential equations are written to describe the evolution of the pumping and signal wave amplitudes; in contrast to previous literature, resonant frequency differences are allowed in the signal and pumping systems. Pure quantum states are assumed and a small signal approximation is used for solving the equations in order to analytically describe the linear stage of signal pulse generation in the field of a short, high-power pumping pulse in the case of double resonance; the pumping is carried out in a system with a common upper level. Analytical expressions are derived for the conditions under which an exponentially increasing signal is generated with an asymptotically constant waveform, moving at the velocity of the pumping pulse. The study of the relationship between the signal pulse and lasing medium and pumping parameters shows that competition between local and wave nonsteady-states is responsible for an optimal pumping pulse energy that is a function of the resonant frequency differences; when this optimal energy is exceeded, the output signal pulse energy decreases. When the initial frequency differences are unequal, the generation of the signal pulse is accompanied by the pulling of the signal frequency to the value needed for frequency difference equality. In the early stages of signal pulse generation, this leads to the breakdown of the pulse into a train of subpulses shorter than the pumping pulse. Sample calculations are shown for atomic vapors of potassium and indium (the 1, 2 and 3 levels are the $4P_{3/2}$, $5P_{3/2}$ and $6S_{1/2}$ for K and $5P_{1/2}$, $5P_{3/2}$ and $6S_{1/2}$ levels for In, respectively) so as to provide numerical parameters for an experimental check. While the numerical data are consistent with expectations, no evidence of an experimental confirmation is provided. Figures 5; references 26: 13 Russian, 11 Western (2 in Russian translation).

THE LASER 'KEY' TO THERMONUCLEAR ENERGY. 7. THERMONUCLEAR PLASMA OF
SPHERICAL LASER TARGETS

[Article by S.Yu. Guskov and V.B. Rozanov]

[Abstract] Target acceleration and compression under the influence of
laser radiation is investigated. The basic characteristics of target
compression, such as the shell acceleration time, velocity, and evaporated
mass, heterodynamic transfer coefficient, temperature, and thermonuclear
plasma density at the moment of collapse are investigated as a function of
the parameters of the target and the laser pulse. The procedures by which the
average temperature and density of the thermonuclear plasma of a shell target
are estimated are explained. The higher the initial entropy, the greater
the resistivity of matter to subsequent compression and the smaller the
final density of the matter. Low entropy is the basic condition for high
compression. Figures 2; references: 6 Russian.

THE LASER 'KEY' TO THERMONUCLEAR ENERGY. 5. ENERGY TRANSFER IN LASER
PLASMA

[Article by S.Yu. Guskov and V.B. Rozanov]

[Abstract] The transfer of absorbed energy to target layers with density
higher than critical, where laser radiation does not penetrate, is analyzed.
The transfer of energy by fast electrons is explained. The intrinsic
radiation of laser plasma is analyzed. The temperature and degree of
compression of different parts of the target are determined from the spatial
and time distributions of the intrinsic radiation of the plasma.

THE LASER 'KEY' TO THERMONUCLEAR ENERGY. 4. ABSORPTION OF LASER RADIATION
IN PLASMA

[Article by S.Yu. Guskov and V.B. Rozanov]

[Abstract] The fundamental mechanisms underlying the absorption of high-
power laser radiation--reverse brehmsstrahlung, resonant, and anomalous
processes--are analyzed. The efficiency of laser radiation absorption in
plasma is investigated. The generation of fast electrons and ions due to
collisionless dissipation of plasma electron vibrations is explained. The
generation of fast electrons is one of the causes of anomalously high
acceleration of some of the plasma ions. It has been found experimentally
that fast ions with energy on the order of several hundreds of kiloelectron-
volts are formed at "corona" temperatures of the order of several kiloelectron
volts.

THE LASER 'KEY' TO THERMONUCLEAR ENERGY. 3. BASIC DIRECTIONS AND CURRENT
STATUS OF RESEARCH

[Article by S.Yu. Guskov and V.B. Rozanov]

[Abstract] Two concepts of laser thermonuclear fusion are outlined and
traced historically: The shaped-pulse concept, in which minimum entropy
is introduced into the system when a uniform spherical target is compressed
by a pulse whose shape changes over time in a specified manner, and hydro-
dynamic shaping, in which a low-entropy compression mode is achieved by
virtue of the structure of the target itself. Experiments conducted during
the 1970s using "slow" and "fast" compression with shell targets are
described. The parameters of the most powerful lasers in existence for
thermonuclear fusion experiments are presented. The current state of work
on laser thermonuclear fusion in the Soviet Union and abroad is reviewed.

EMISSION CHARACTERISTICS OF Al_2O_3:Ti^{3+}-CRYSTAL LASER WITH COHERENT PUMPING

[Article by G.S. Kruglik, G.A. Skripko, A.P. Shkadarevich, N.V. Kondratyuk, and E.A. Zhdanov, Belorussian Polytechnic Institute, Minsk]

[Abstract] An experimental study of Al_2O_3 crystals with up to 0.5 wt.% Ti^{3+} was made, for the purpose of determining their spectroscopic and emission characteristics under conditions of coherent optical pumping, the corundum crystals for this study having been grown by the Verneuil method and doped preferentially with tetravalent titanium and trivalent titanium. A high and uniform concentration of active Ti^{3+} centers was obtained by subsequent thermochemical tinting, resulting in crystals with an absorption coefficient up to 2 cm^{-1} at the 490 nm wavelength of the absorption peak within the visible region of the spectrum and in emission from crystals only 1.5 mm thick. The luminescence of all crystals pumped by an Ar-laser was found to be intense and of 3.7 μs duration, independently of the Ti content up to 0.5 wt.% and of the temperature from 4.2 K to 293 K. While their absorption spectra were characterized by a low intensity over the wide 700-1000 nm range of wavelengths, their luminescence peak shifted from the 753 nm wavelength at 4.2 K to the 787 nm wavelength at room temperature with a simultaneous increase of intensity within the long-wave wing but without a fine structure at any temperature. The crystals were then pumped with second-harmonic radiation from a garnet laser (532 nm wavelength, 10 ns pulse duration) using a nonselective plane resonator, through an "opaque" mirror with a reflection coefficient R = 0.99 for the 700-900 mm wavelengths and R = 0.22 for the 532 nm wavelength. Thermochemically tinted crystals 10 mm long and 8 mm in diameter emitted pulses of duration ranging from 2 ns to 13 ns as the resonator length was increased from 20 mm to 180 mm, with the emission power almost equal to the pumping power at optimum resonator length, maximum output energy, and maximum conversion efficiency. Crystals with 0.15 wt.% Ti^{3+} and 40 mm long were smoothly tunable over the 706-910 nm range with a 25% efficiency at the peak with a 43%-reflection exit mirror and over the 675-945 nm range with a 17% efficiency at the peak with a 98%-reflection exit mirror. The crystals were also pumped with radiation from a rhodamine 6G (dye) laser (λ = 590 nm wavelength, Δλ = 5 nm, pulse energy up to 100 mJ, pulse duration 4 μs), for a determination of their free-emission characteristics. They emitted spikes of 120 ns duration, in the first approximation independent of the resonator length and of the pumping intensity, but the number of spikes increases as the pumping intensity was increased and the distance between them shrank to 300 ns at a pumping level 200% above the threshold. Figures 6; references 8: 1 Russian, 7 Western.

SYNCHRONOUSLY EXCITED PICOSECOND DYE LASER WITH SUPERFINE ADDITIONAL
RESONATOR

[Article by K.D. Yegorov, V.A. Nekhayenko, S.M. Pershin, S.A. Pleshanov,
A.A. Podshivalov, and V.V. Shuvalov, Moscow State University imeni M.V.
Lomonosov]

[Abstract] The performance of a picosecond frequency-tunable dye laser with
synchronous second-harmonic pumping by a solid-state laser with passive
mode locking is analyzed, pulses of up to 5 ps duration with a power of up
to 50 kW being generated by a new method which involves use of two coupled
resonators: an external one matched to the resonator of the pumping laser
and a superfine one containing the active medium. The mathematical analysis
is based on the theory of transient-state emission from a multilevel active
medium with nonsteady polarization of the working transition. The correspond-
ing system of two equations of emission dynamics, with appropriate initial
and boundary conditions, are solved for field amplitude and gain after the
n-th passage through a resonator. Averaging these equations is permissible
when the duration of a pumping pulse exceeds by far the transit time through
the active medium. Experiments were performed with a dye (S160) laser and
pumping by pulse trains from either a YAG:Nd laser (5 mJ - 40 ps pulses) or
a KNPS laser (6 mJ - 10 ps pulses) with frequency doubling by a nonlinear
crystal and passive mode locking. Frequency tuning was done with a set of
three 60° prisms and a diaphragm, synchronization was done by moving a plane
mirror with a 1.0 reflection coefficient back or forth behind the last prism.
The duration of an emission pulse was measured while the thickness of the
superfine resonator with active medium was varied over the 0.2-3.5 mm
range and the dye concentration was varied but so as to always ensure 90-
95% absorption of the pumping energy. The results reveal an almost constant
pulse duration within an emission pulse train and its direct linear dependence
on the thickness of the superfine resonator (layer of active medium) over wide
ranges of pumping pulse train characteristics, namely pulse duration and
number of pulses, at pumping levels 50-100% above the threshold. Figures 7;
tables 1; references 12: 8 Russian, 4 Western.

OPTIMIZATION OF $BaYb_2F_8$:Er LASER MEDIUM

[Article by B.M. Antipenko, V.A. Buchenkov, A.A. Niktichev, B.P. Sobolev, A.I. Stepanov, L.K. Sukharova, and T.V. Uvarova]

[Abstract] An experimental study of the $BaYb_2F_8$:Er laser medium was made, for the purpose of determining the dependence of its emission characteristics on the Er-activator concentration and consequently finding the optimum activator concentration with respect to emission at the 1.96 µm wavelength in the $^4F_{9/2}$ - $^4I_{11/2}$ channel. A series of $BaYb_2F_8$:Er crystals 40 mm long and 5 mm in diameter was tested in the free lasing, with almost square pumping pulses of 1.2 µs duration. The pumping source was an ISP-250 flash lamp in an elliptical silver-coated monoblock luminaire. The resonator was formed by plane dielectric mirrors with a 0.93 reflection coefficient at the emission wavelength. The threshold pumping energy and the differential efficiency as well as the output energy at constant 200 J pumping energy were measured, each crystal having a different Er^{3+}-ion concentration relative to the number of Yb sites. The results reveal that the threshold pumping energy is minimum while the differential efficiency and the output energy are maximum within the 8-11% Er^{3+}-ion concentration range. The drop of differential efficiency as the Er^{3+}-ion concentration exceeds 11% of the Yb sites is attributed to higher active and inactive losses rather than to a lower energy extraction efficiency. The nature of energy losses is examined in the light of energy levels. Following a verification of the hypothesis that quenching of the $^4I_{13/2}$(Er) level occurs in the process of nonlinear deactivation and enhances excitation of the $^4F_{9/2}$(Er) level on the basis of experiments with a YAG:Er laser and kinetics of $BaYb2F8$:Er luminescence at the 1.5 µm wavelength upon pumping by an erbium glass laser at the 1.54 µm wavelength, subsequent calculations with a first-order correction to the population of the $^4F_{9/2}$(Er) level and including additive excitations of the $^4I_{13/2}$(Er) level confirm the results of this study. Figures 4; references 6: all Russian.

HIGH-PRESSURE MULTICOMPONENT-GAS KrF-LASER

[Article by W.J. Witteman, Tvent Technological University, Enschede (Netherlands)]

[Abstract] A study of KrF as a gaseous laser medium with electron-beam pumping was made, for a determination of its performance characteristics under high pressure up to 12 atm and high current density up to 375 A/cm^2 with a uniform excitation distribution over the Kr-F_2 mixture alone or with a buffer gas. The apparatus was essentially a coaxial vacuum diode directly coupled to a 10-stage low-inductance Marx generator. The dry-air discharge gaps in each 7.2 nF - 1 kohm stage, consisting of eight 1.8 nF $BaTiO_3$ capacitor pairs, were excited by ultraviolet radiation from the preceding discharge gap so that only the first discharge gap had to be excited by means of an external signal. The generator was placed inside a cylindrical vessel 1 m high and 0.25 m in diameter, containing SF_6 under a pressure of $4 \cdot 10^5$ Pa sufficient to prevent breakdown. The generator was capable of delivering pulses of 100 J energy at a voltage of 600 kV. The cathode of the laser cell was a 20 cm long hollow cylinder with an inside diameter of 5 cm, rounded edges at both ends preventing field emission and two 20 cm long and 0.7 cm wide porous graphite strips parallel to the axis ensuring bilateral transverse excitation in an electric field with radial symmetry. The anode of the laser cell was a 20 cm long tube made of 50 μm thick titanium foil, its inside diameter of 1 cm providing an active volume of 16 cm^3. At each end of the laser cell was mounted an MgF_2 window, one with a quartz roof-prism for total reflection of light and one for extraction of radiation energy. All experiments were performed with a discharge voltage of 280 kV and 7.5 kA current pulses of 30 ns duration, approximately 375 A/cm^2 maximum current density and 250 A/cm^2 average current density with the maximum electron energy in the laser cell reaching 170 keV. Measurements for determining the dependence of the laser output energy on the total gas pressure were made with a Kr + F_2 medium alone, with Ar as buffer gas in various concentrations, and with Ar gradually replaced by Ne. Maximum energy from a Kr + F_2 mixture alone was extracted with partial pressures p_{F_2} = 10 mbar and p_{Kr} = 2 atm. This optimum partial pressure of F_2 was subsequently maintained while buffer gas was added and the partial pressure of Kr was also varied. The optimum mixture with Ar as buffer gas was p_{Ar} = 4.5 atm and p_{Kr} = 0.5 atm. Substitution of Ne for Ar was found to have a favorable effect, namely to further increase the output energy. An extrapolation of the results indicates that the optimum partial pressure of Ne in this system would be p_{Ne} = 15 atm. A theoretical analysis of the results has yielded data on the quenching coefficients for the three gases Kr, Ar, Ne in such a collisional system. Article was presented at the 12th All-Union Conference on Coherent and Nonlinear Optics in Moscow, August 1985, and translated from English by A.S. Semenov. Figures 12; tables 1; references 9: all Western.

MAGNETOHYDRODYNAMICS

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA DURING DIFFUSION OF
MAGNETIZABLE MEDIA

[Article by A.O. Tsebers and A.Yu. Chukhrov]

[Abstract] Numerical simulation of diffusion processes in a ferromagnetic
fluid under dynamic action of its nonuniform intrinsic field is considered,
taking into account flow kinetics and convection. Numerical experiments
based on the system of three field equations for plane flow, covering the
velocity field and the concentration field as well as the potential of the
intrinsic field, reveal the possibility of cellular flow and free convection
when a horizontal layer of uniform thickness and with uniform concentration
gradient separates two regions with different uniform concentrations of
particles in a uniform external magnetic field parallel to the concentration
gradient vertically upright. Figures 5; references 7: 2 Russian, 5 Western
(1 in Russian translation).

TURBULENT FLOW OF MAGNETORHEOLOGICAL SUSPENSIONS AND ATTENDANT HEAT TRANSFER

[Article by Z.P. Shul'man, V.I. Kordonskiy, and S.R. Gorodkin]

[Abstract] Turbulent flow of heterogeneous media consisting of noncolloidal
ferromagnetic particles suspended in a carrier fluid is analyzed, considering
that the behavior of such a system is controllable by an external magnetic
field. Calculations are made for a stream of fluid with low concentration
of particles flowing through a channel of circular cross-section. In the
absence of a magnetic field these particles are assumed to move together

with oscillating carrier volume elements and thus do not influence the flow pattern. For the purpose of determining the effect of an external magnetic field on the integral characteristics of this stream, namely the hydraulic drag and the heat transfer to the channel wall, an experimental study was made with a less than 1% aqueous suspension of iron (carbonyl R-10) particles of average 3.5 μm diameter. The test segment of the channel was a 1 m long copper tube 8 mm in diameter, surrounded by an electric heater coil producing a uniform thermal flux distribution (boundary conditions of the second kind) and thermally insulated on the outside. Flow and temperatures were measured with inductive pressure transducers and thermocouples respectively, pressure readings having been corrected for the effect of a magnetic field as well as for their dependence on the flow rate and the particle concentration. Tests were performed with a uniform transverse magnetic field and with a uniform longitudinal one. The results were found to differ from those for colloidal ferromagnetic suspensions both the hydraulic drag coefficient and the Nusselt number increase fast with increasing intensity of a transverse magnetic field and decrease at a nonmonotonic rate, which peaks at some intermediate value of the Alfven number, with increasing intensity of a longitudinal magnetic field. Figures 8; references 11: 8 Russian, 3 Western (1 in Russian translation).

MOTION OF AXISYMMETRIC MAGNETICALLY SOFT PARTICLE IN HYDRODYNAMIC STREAM IN STRONG ROTATING MAGNETIC FIELD

[Article by Z.P. Shul'man, B.M. Khusid, and E.A. Zal'tsgender]

[Abstract] Motion of a rigid axisymmetric magnetically soft particle in a magnetic field which varies in both time and space is considered, assuming a sufficiently strong magnetic field and a sufficiently small particle with negligible inertia. For analyzing the dynamics of this motion in an arbitrarily flowing fluid, an appropriate rotating system of coordinates is selected most convenient for the case of a magnetic field with an orientation of its vector arbitrarily varying in space. Calculations are made first for a particle moving with the fluid and then for a particle moving relative to the fluid. Special cases of greatest practical importance are a magnetic field vector remaining in one plane and a magnetic field vector varying in magnitude only. Slow rotation of the magnetic field is considered, with a period much longer than the characteristic relaxation time, and as specific examples are considered six different orientations of the plane hydrodynamic flow field relative to the plane magnetic field. Figures 3; references 11: 9 Russian, 2 Western (1 in Russian translation).

OPTICS AND SPECTROSCOPY

STATISTICS OF LASER RADIATION PHOTOCOUNTS AFTER PASSAGE THROUGH TURBULENT
ATMOSPHERE

[Article by A.T. Mirzayev, M.N. Mamatkulov, and I.K. Rasulov, Tashkent
State University imeni V.I. Lenin]

[Abstract] Experimental photocounting of laser radiation was done with a
He-Ne laser in a mountainous locality, the purpose being to establish the
photocount statistics for applications such as optical radar or atmosphere
probing. With both transmitter and receiver on level ground, the light
beam traveled a $2L = 1$ km long distance from the transmitter through a
telescope up to a reflector 200 m above and down to the receiver with a
multichannel photon counter through an interference filter and a diaphragm.
Nowhere was the light beam farther than 80 m from the uneven ground surface.
A statistical analysis of the photocounts has yielded a probability distribu-
tion $P(n)$ shifting toward smaller numbers n of photocounts and approaching
an exponential one as the atmospheric turbulence increases. Figures 2;
references 4: 3 Russian, 1 Western.

GENERATION AND AMPLIFICATION OF ULTRASHORT LIGHT PULSES BY MEANS OF
EXCIMER LASERS

[Article by S.A. Akhmanov, A.M. Val'shin, V.M. Gordiyenko, M.S. Dzhidzhoyev,
S.V. Krayushkin, I.A. Kudinov, V.T. Platonenko, V.K. Popov, and V.D. Taranukhin,
Moscow State University imeni M.V. Lomonosov]

[Abstract] An apparatus including two excimer lasers is described which can
produce ultrashort light pulses of ultraviolet to infrared wavelengths,
depending on the active medium of those lasers. Excimer lasers are,
despite their intricate structure, particularly suitable for this purpose,
because of their large cross-section for induced transition ($\sigma \approx 10^{-16}$ cm^2)
and wide amplification band ($\Delta\nu \sim 100$ cm^{-1}). The probability of parasitic
emission and superluminescence must, however, be minimized. The apparatus
includes, in addition to the excimer laser-generator and laser-amplifier,
also a solid-state ($YAlO_3:Nd^{3+}$) master laser with passive mode locking and
electronic Q-switching, a dye (C160) laser-generator with synchronous pump-
ing tuned to double the principal wavelength, and a dye (C160) laser-
amplifier. For producing ultrashort ultraviolet pulses at the $\lambda_1 = 308$ nm
wavelength, the dye laser-generator was transversely pumped by the XeCl
excimer laser-generator and emitted narrow-spectrum pulses of 6 ± 2 ps duration,
which were amplified by the dye laser-amplifier and converted into second-
harmonic pulses (wavelength $\lambda_1 = 308$ nm) by an ADP crystal. These pulses
proceeded to the first stage of the excimer laser-amplifier containing a
trielectrode discharger and an HCl:Xe:He = 1:10:1000 active mixture, also a
resonator formed by an opaque plane aluminum mirror and a quartz substrate.
Pulses from the dye laser-generator were passed through an optical fiber
for spectrum widening to 100 cm^{-1} and through a KDP crystal for frequency
doubling. With this equipment were produced ultraviolet pulses of 5 ps
duration and 15 mJ maximum energy, thus with a power of 5 GW. The authors
thank A.A. Podshivalov for assisting in the experiments. Figures 5;
tables 1; references 9: 6 Russian, 3 Western.

ACOUSTOOPTICAL INTERACTION IN Ta$_2$O$_5$-SiO$_2$-GaAs WAVEGUIDE

[Article by S.A. Gurevich, S.M. Kikkarin, D.V. Petrov, V.I. Skopina, F.N. Timofeyev, A.V. Tsarev, and I.B. Yakovkin]

[Abstract] An experimental study of a Ta$_2$O$_5$-SiO$_2$-GaAs waveguide structure, a structure with low optical losses and a weak temperature dependence of refractive indexes, was made for the purpose of evaluating the acoustooptical interaction in it and determining the feasibility of its monolithic interfacing to a semiconductor laser. A specimen of such a structure was produced by chemical deposition of SiO$_2$ buffer layers and Ta$_2$O$_5$ waveguide layers on an i-GaAs<Cr> substrate ($\rho \sim 10^6$-10^7 ohm·cm, $n \sim 10^{12}$-10^{13} cm^{-3}). Light at the λ_0=633 nm wavelength from a He-Ne laser was led in and led out through Bi$_2$(GeO$_3$)$_3$ prisms. The waveguide maintained three TE modes and three TM modes. Three interdigital transducers with 50 pairs of bars each were photolithographically deposited on the surface of this structure for excitation of surface acoustic waves with 26 µm, 20 µm, 10 µm wavelengths respectively, but only the first two of them actually excited surface acoustic waves at frequencies of 111 MHz and 144 MHz respectively. This is explained on the basis of a quantitative waveguide design analysis and SAW characteristics. In the waveguide was also obtained acoustooptical interaction of 111 MHz and 144 MHz surface acoustic waves with light at the λ_0=879 nm wavelength from a GaAs-laser. With either light, the Bragg diffraction efficiency was found to be much higher in the TM$_0$-TM$_0$ process than in the TE$_0$-TE$_0$ process. The authors thank S.N. Svitasheva for making the ellipsometric measurement and E.N. Kiseleva for preparing the interdigital transducers. Figures 1; tables 1; references 5: 2 Russian, 3 Western.

MEASUREMENT OF SPECTRAL CHARACTERISTICS OF MULTILAYER X-RAY MIRRORS WITH AID OF RADIATION FROM LASER-GENERATED BERYLLIUM RECOMBINATION PLASMA IN FAR DISPERSION ZONE

[Article by S.V. Bobashev, I.G. Zabrodin, Yu.Ya. Platonov, N.N. Salashchenko, D.M. Simanovskiy, and L.A. Shmayenok]

[Abstract] The spectral characteristics of multilayer x-ray mirrors were measured by the method of recording the emission line of a laser-generated recombination plasma, in the far zone of plasma dispersion. Farther than 1 cm away from the target center the radiation emission characteristics of such a plasma are determined by only one relaxation process, namely triple recombination of ions and electrons through high excited states. A

beryllium target in a vacuum chamber was treated with radiation pulses of 10-50 J energy and 50 ns duration (power 10^{13} W/cm^2) from a Nd-laser. Measurements were made with a ϕ-2ϕ goniometer containing one of the x-ray mirrors and a CsI-coated herringbone multilayer Ni-C detector of ultrasoft x-radiation. The intensity of radiation reflected by the mirror was normalized to the intensity of radiation from the same ions in the vacuum-ultraviolet range, which eliminated the error due to plasma radiation intensity fluctuations. Figures 2; references 8: 5 Russian, 3 Western.

2415/9835
CSO: 1862/58

FORM OF DUAL RF OPTICAL RESONANCE LINE USING NONLINEAR OPTICAL INDICATION

[Article by L.A. Budkin, M.N. Penenkov, A.I. Pikhtelev, and V.L. Mikhaylovskiy]

[Abstract] The characteristics of lasing with an intra-cavity absorption cell and of the dual RF optical resonance signal are investigated on the basis of a system of equations for the density matrix of three-level working atoms considering the occurrence of coherence on the nonresonance optical transition. The amplitude of the dual RF optical resonance signal can be increased by selecting the parameters of the nonlinear indication system and narrowing the line to a value on the order of the "dark" width. Figures 4; references 7: 6 Russian, 1 Western.

6900/9835
CSO: 1862/228

LIGHT SCATTERING BY DIELECTRIC SPHEROIDS. IV.

[Article by N.V. Voshchinnikov and V.G. Farafonov]

[Abstract] This study examines scattering of an obliquely incident plane TE-type wave, with the electrical field intensity vector perpendicular to the plane of incidence of the radiation, by an elongated or flattened spheroid. Differences in boundary conditions as compared with TM-waves makes it necessary to solve structurally more complex infinite systems of linear algebraic equations from which the expansion coefficients of the scattered radiation field are determined. An algorithm is presented for calculating the attenuation efficiency Q_{ext}^{TE} for spheroids with indices of refraction of m = 1.2 and 1.33 and half-axis ratios of a/b = 2-5 for different angles of incidence of the radiation. The Q_{ext}^{TE} for large values of α is somewhat smaller than for elongated spheroids, and somewhat greater than for flattened spheroids. Figures 3; tables 1; references 8: 4 Russian, 4 Western.

6900/9835
CSO: 1862/236

1-DOUBLING IN MICROWAVE SPECTRUM OF LINEAR MOLECULES INTERACTING WITH RESONANT IR RADIATION

[Article by A.A. Kiselev, A.V. Lyaptsev, and A.N. Zuyev]

[Abstract] A three-atom linear molecule in a strong monochromatic field in resonance with the transition from the primary to the first excited state of the deformation oscillation is investigated. The behavior of the molecules in the periodic field is described by the quasienergy-state method. The electrical dipole transitions in the microwave absorption spectrum of the test field are examined. Spectral line broadening due to the Doppler effect is investigated. Figures 3; references 31: 17 Russian, 14 Western.

6900/9835
CSO: 1862/236

INFLUENCE OF GAS DENSITY ON FORM OF Q-BRANCHES OF CO_2 IR ABSORPTION BANDS IN 5 μm REGION

[Article by A.B. Dokuchayev, A.Yu. Pavlov, Ye.N. Stroganova, and M.V. Tonkov]

[Abstract] The formation of the contour of the Q-branch in the IR absorption spectra of CO_2 is examined. The Q-branches of the $\nu_1+\nu_2$ and three ν_2 bands, which represent Fermi doublet components, are investigated. These bands exhibit significant deviations in the distribution of the intensities of the vibrational-rotational lines from those calculated using the approximation of a rigid rotator, which is associated with strong Coriolis interaction. The spectra of mixtures of CO_2 with He, Ne, Ar, and Xe are obtained for pressures of 2-50 atm with CO_2 concentrations from 1 to 5% at 292 K. The branches become more symmetrical, and their width increases far more slowly, as the pressure increases than is predicted by calculation using summation with Lorenz contours. The maximum of the branch moves toward higher frequencies in the case of helium, and remains practically unchanged in the case of xenon. These effects are found to be associated with spectral exchange within the Q-branch, as well as between the Q and P branches. Figures 5; references 8: 2 Russian, 6 Western.

ATOM BEAM COMPRESSION BY PRESSURE FROM LASER RADIATION

[Article by V.G. Minogin]

[Abstract] The existence of laser field configurations in which it is possible to compress atom beams by the radiation pressure is investigated. The idea of atom beam compression is based on exploiting the interaction between atoms and spatially heterogeneous light fields in which the light pressure creates a potential well across the axis of the beam and simultaneously retards transverse movement of the atoms. It is found that an atom beam can be compressed by the pressure of resonant radiation to dimensions on the order of the Gaussian beam diameter; because the smallest value of the latter can be on the order of the light wave length λ, the atom beam can have a transverse dimension close to the wavelength of the light field. It is

noted that the compressing fields can exhibit different configurations, and that the beam can only be compressed in spatially heterogeneous fields. The compression of atom beams to transverse dimensions of hundreds or tens of microns is of interest in numerous areas of atomic physics, optics, and spectroscopy, especially in research on collective effects in ensembles of atoms. Figures 2; references 7: 4 Russian, 3 Western.

PICOSECOND-LONG ACTIVE SPECTROSCOPY OF RAMAN SCATTERING IN BIOLOGICAL OBJECTS

[Article by V.G. Kamalov, N.I. Koroteyev, B.N. Toleutayev, A.Yu. Chikishev, and A.P. Shkurinov, Moscow State University imeni M.V. Lomonosov]

[Abstract] Active spectroscopy of Raman scattering is considered for analysis of molecular vibrations in biological objects, this method being generally preferable to spectroscopy of spontaneous or resonant Raman scattering because of a stronger and more precisely directional signal as well as higher spectral resolution determined by width of the laser line only. This method is based on three-wave interaction in a medium with cubic susceptibility. The fourth wave generated as a result carries information about the medium without undesirable background luminescence, since the probing signal is dispersed into the antiStokes short-wave range. Conventional pulse lasers used for active spectroscopy are too powerful for biological media, causing thermal breakdown of the latter even with a short pulse. A spectrometer has therefore been developed with all the favorable features, including a laser which delivers high pulse power but low average power. Its main components are a YAG:Nd^{3+} laser with mode locking and acoustooptic Q-switching, which emits pulses of 80-85 ps duration and 0.7 MW peak power at the λ = 1.06 μm wavelength, two $LiIO_3$ crystals for frequency doubling, an "AGAT" camera with light filter for monitoring the pulse duration, a dye (rhodamine 6G in ethylene glycol) laser with modified N.W. Kogelnik resonator using a diffraction grating as dispersive element, an electrooptic modulator, a 70° Fresnel rhombus acting as polarizer for separate linear polarization of pumping radiation from the YAG:Nd^{3+} laser (second harmonic) and from the dye laser, a 90° prism with double total internal reflection acting as delay line, a dichroic mirror, the test cell bewteen two lenses followed by a diaphragm, a Glan prism acting as polarization analyzer, an interference filter, and a double monochromator with a photomultiplier acting as photon counter. Auxiliary components include three beam-splitting mirrors, two 90° opaque mirrors, a photodiode, a phototransistor, and a lens between the interference filter and the double

monochromator. The photon count is transmitted to a multichannel analyzer
for processing in a CAMAC crate with an "Elektronika-80" microcomputer in
dialog and a graph plotter. The spectrometer was used for obtaining
vibration spectra of proteolytic o-chymotrypsin (albumen-enzyme).
Figures 2; references 10: 4 Russian, 6 Western.

2415/9835
CSO: 1862/262

DETECTION AND ANALYSIS OF OSCILLATING ELECTRIC FIELDS IN PERIPHERAL TOKAMAK
PLASMA ON BASIS OF NEW SPECTROSCOPIC EFFECT

[Article by V.P. Gavrilenko, Ye.A. Oks, and V.A. Rantsev-Kartinov, VNITsPV (?)]

[Abstract] In an experiment with a T-10 tokomak, peripheral plasma was
detected and diagnosed on the basis of the deuterium luminescence spectrum.
The instrumentation for this purpose included a 10-channel polychromator
with 0.6-0.7 Å resolution consisting of an MDR-2 monochromator with fiber
optics and an array of photomultipliers. The main feature of D_α, D_β, D_γ
spectral lines are dips at the center of both D_α and D_γ profiles but no dip
at the center of the D_β profile. Those π-profiles with dips correspond
to emission of radiation polarized parallel to the magnetic field vector
B_0, not possibly a Zeeman split but only the Stark effect in an anisotropic
electric field being possibly responsible for the dips. Such spectral
characteristics observed in a magnetic field of intensity $B_0 = 1.65$ T are
the results of a superposition of a high-frequency quasi-monochromatic
electric field and a quasi-static electric field also parallel to the
magnetic field vector. The profiles of the deuterium lines change
appreciably, from π-profiles to σ-profiles, as the magnetic field intensity
is increased up to 3.05 T. An evaluation of the experimental data on the
basis of this new spectroscopic effect indicates that, at least in the
peripheral plasma of a T-10 tokomak, at high current and low density there
build up oscillations whose electric fields reach 10-20 kV/cm intensity
levels. Figures 3; references 3: 2 Russian, 1 Western.

NONEQUILIBRIUM RADIATION EMISSION FROM PLASMA OF LASER TARGETS

[Article by B.N. Bazylev, F.N. Borovik, G.A. Vergunova, S.I. Kas'kova, V.B. Rozanov, G.S. Romanov, L.K. Stanchits, K.L. Stepanova, and A.V. Teterev, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] Radiation emission characteristics of laser targets are analyzed and evaluated on the basis of the radiation-collision model of a plasma, which yields a coronal distribution in the extreme case of high temperature and low electron concentration and a Boltzmann-Saha distribution in the extreme case of high electron concentration and low temperature. The problem of heating, compression, and dispersion dynamics has been solved by numerical methods for two glass targets, respectively 0.5 µm and 1.5 µm thick spherical shells with a 200 µm radium each and filled with hydrogen each, receiving radiation from a Nd-laser in ramp pulses of 4.4 ns duration and with a 120 GW peak power. The plasma model takes into account the generally appreciable thermodynamic nonequilibrium as well as the transparence of a target plasma. Absorption and emission coefficients as well as radiation losses are calculated on this basis, whereupon the radiation transfer equation is solved for specific values of target and radiation emission parameters. Contributions of five radiation mechanisms, namely bremsstrahlung, photorecombination, discrete-spectrum radiation, and radiation from the central hydrogen nucleus to the total radiation power have been separately evaluated for both target shells. The equation of radiation transfer is then modified by inclusion of the source function for the more general case with resonant radiation scattering along spontaneous decay of the upper state. As a special case is considered heating of cold and compression-free inner layers of a target by intrinsic radiation. Figures 7; tables 2; references 22: 16 Russian, 6 Western.

EXPERIMENTAL CONFIRMATION OF ABRUPT CHANGES IN PLASMA PARAMETERS IN GAS DISCHARGE

[Article by V.N. Babichev, F.I. Vysikaylo, and S.A. Golubev]

[Abstract] Theoretically predicted abrupt changes, drift jumps, of plasma parameters such as the electric field intensity have been confirmed experimentally under conditions of departure from quasi-neutrality. In a stream of extra-pure nitrogen flowing between two electrodes inside a glass tube (length 45 cm, diameter 3.9 cm) was ignited a steady discharge in the direction of gas flow. This discharge was uniform, except within the parelectrode regions. The pumping action was controlled so that the gas velocity and the gas pressure could be varied, over the 1-100 m/s range and over the 0.1-4 kPa range respectively. The magnitudes and the locations of these electric field intensity and glow intensity jumps were found to correspond to discontinuities in the drift solution to the model equations and to be analogous to shock wavefronts in gas dynamics. The authors thank L.D. Tsendin for discussion. Figures 1; references 6: all Russian.

LASER-PLASMA DETECTION

[Article by B.I. Vasilyev, A.Z. Grasyuk, L.L. Losev, and Ye.A. Meshalkin]

[Abstract] The generation of ultrahigh frequency currents during optical breakdown at the surface of a charged metal target irradiated by intensity-modulated laser radiation, termed laser-plasma detection, is investigated. High-power laser pulses were obtained using an optical set-up described in the article by aiming two light beams with fixed intensity and different frequencies toward the target. The experiments indicated that velocity-modulated broadening of the conducting region near the metal charged target is the fundamental mechanism underlying laser-plasma detection of the difference frequencies of two waves from an Nd laser. Plasma glow modulation, in conjunction with the current modulation, are achieved most effectively when the coefficient of absorption of the laser radiation in the breakdown plasma is high. It is therefore concluded that IR lasers are most promising for such applications; a UV laser can be used to create the plasma on the target surface. It is noted that the laser-plasma detection effect can also be observed when a conducting area is formed near a charge target by ionizing the gas surrounding the target by means of a UV laser. Figures 7; references 17: 15 Russian, 2 Western.

MATHEMATICAL MODELING OF CO_2 DISSOCIATION IN SUPERSONIC STREAM OF NONEQUILIBRIUM PLASMA

[Article by T.M. Grigoryev, A.A. Levitskiy, L.S. Polak, B.V. Potapkin,
V.D. Rusanov, and A.A. Fridman, Institute of Petrochemical Synthesis
imeni A.V. Topchiyev, USSR Academy of Sciences]

[Abstract] Dissociation of CO_2 in a quasi-one-dimensional supersonic
stream of a nonequilibrium plasma is described fully, by supplementing
the equation of dissociation reaction $CO_2 \rightarrow CO + 1/2O_2$ with the equation of
state for an ideal gas and seven differential equations of gasdynamics
and chemical kinetics. They are the equations of continuity for the
chemical mixture and for each of its three components, the equation of
momentum conservation, the equation of overall energy balance, and the
equation of energy balance for the antisymmetric mode of CO_2 oscillations.
The antisymmetric mode is excited by electron impact and is attenuated by
VT-relaxation. The equation of its energy balance is formulated so as to
also account for energy exchange with other modes and for chemical
reactions. With the rate constants of all reactions and other processes
expressed in proper exponential form with known numerical values of
parameters, this system of equations was solved on a NOVA-3 computer with
a 64 kbyte direct-access memory. Difficulties arising from rigidity
of this mathematical model were overcome by use of the DIFSUB subroutine
based on the C.W. Gear algorithm. The obtained information included
dependence of the energy efficiency and of the conversion yield
$[CO]/[CO_2]$ of dissociation inside a reactor with uniform cross-section
on the input energy density for various initial temperatures, plasma
charge concentrations, and plasma stream velocities. Figures 1; tables 1;
references 12:

2415/9835
CSO: 1862/255

CRYOGENIC GUIDE TUBE WITH RENEWABLE SURFACE COATING OF D_2O ICE FOR ULTRACOLD NEUTRONS

[Article by V.I. Morozov, Yu.N. Panin, and Ye.V. Rogov]

[Abstract] The feasibility of a horizontal guide tube with D_2O ice for extraction of ultracold neutrons from the moderator of a nuclear reactor has been established experimentally. Tests were performed with D_2O ice coating on the electrolytically polished inside surface of a 2 m long and 4 m in diameter tube of stainless steel, inside a cooling jacket with nitrogen at a temperature of 80 K. Its reflection and absorption characteristics were measures at that temperature and also at 300 K, whereupon the neutron storage life was determined from readings of the neutron flux parameters. The storage life was found to depend on the thickness of the ice coating, increasing to a maximum of 150 s with a coating of approximately 200 mg/cm and then decreasing most probably owing to surface roughness. The results indicate that such a tube 50 bores long will transmit a neutron gas with losses not exceeding 15%, the advantage of D_2O ice coating being its regular renewability and thus assurance of an unlimited tube life. Figures 2; references 8: 6 Russian, 2 Western.

2415/9835
CSO: 1862/58

INVESTIGATION OF DECAY CHARACTERISTICS OF GIANT DIPOLE RESONANCE OF ^{32}S
NUCLEUS BY (γ, $X_{\gamma 1}$) REACTION METHOD

[Article by U.R. Arzibekov, A.S. Gabelko, M.Kh. Zhalilov, K.M. Irgashev,
B.S. Ishkhanov, I.M. Kapitonov, I.M. Piskarev, and F.Sh. Khamrayev, Moscow,
State University imeni M.V. Lomonosov]

[Abstract] The (γ, $X_{\gamma 1}$) reaction method is used to investigate the decay
characteristics of the giant dipole resonance of the ^{32}S nucleus. The
experiments were conducted on the betatron belonging to the Scientific
Research Institute for Nuclear Physics at Moscow State Univeristy. The γ-
quantum spectrum was analyzed for the 0.6-10 MeV range with an upper
bound of the γ beam of $E_\gamma^{max} = 32$ MeV. The γ spectra were processed by the
ACTIV program running on an ES-1022 computer. The nature of the γ-lines
was interpreted with allowance for data on cascade gamma-transitions.
Partial population cross-sections of the level of the ^{31}P nucleus with
energies of 6.34 and 6.91 MeV were determined for the first time. Tables 2;
references 20: 7 Russian, 13 Western.

RADIATION COHERENCY OF TARGET ELECTRONS IN ATOMIC COLLISIONS

[Article by M.Ya. Amusya, A.V. Korol, and A.V. Solovyev, Physico-
Technical Institute imeni A.F. Ioffe, Academy of Sciences, USSR,
Leningrad]

[Abstract] It is shown that atomic braking radiation (BR) which originates
as the result of the polarization of a multielectron atom by a scattered
high-speed particle prevails on a background of braking radiation with
ionization or excitation of a target in the range of frequencies
$I \lesssim \omega \lesssim \nu R_{AT}^{-1}$ (I = ionization potential of atom, R_{AT} = its dimension, ν = velocity
of incident particles). This makes it possible to detect the atomic BR,
measuring only the complete radiation spectrum. The coherency of radiation
of the target atom electrons in the range of frequencies shown above has
a universal nature. It does not depend on the nature of the interaction
of incident particles with the electrons, and prevails for relativistic and
nonrelativistic velocities of a scattered particle which can be heavy
(proton) as well as light (electron). The authors thank M.Yu. Kuchnev for
helpful discussion and critical comments. References 8: 7 Russian,
1 nonRussian.

MEASUREMENT OF CROSS-SECTIONS FOR FISSION OF HEAVY NUCLEI INDUCED BY 16 MeV
NEUTRONS

[Article by A.A. Goverdovskiy, A.K. Gordyushin, K.D. Kuz'minov,
V.F. Mitrofanov, and A.I. Sergachev]

[Abstract] The cross-sections for fission of ^{232}Th, ^{234}U, ^{236}U were
measured, or rather the ratios of these cross-sections to that for fission
of ^{235}U, with the T(d,n) ^{4}He reaction in a 0.8 mg/cm^2 thick Ti-T target as
neutron source. The measurements were made in a continuous deuteron beam
of the KG-2.5 accelerator at the Institute of Power Engineering Physics,
with a ^{232}Th-^{235}U pair as detector of fission fragments inside the ionization
chamber for monitoring the environment. The readings were subsequently
corrected for differences in detection sensitivity, for background neutron
noise, for full moderation of fission fragments in the targets, for inelastic
scattering of neutrons by the ionization detector and the target substrates,
also by the target holder, for fission of minority isotopes, and for noise
from (n,α), (n,p), or other companion reactions. The total error breaks
down into a random component and a weighing error, an error in determination
of the ^{235}U content in targets, an error in extraction of the ambient neutron
noise, and errors in the corrections. Figures 2; tables 2; references 7:
1 Russian, 6 Western.

2415/9835
CSO: 1862/266

MULTIPLICITY OF CHARMED MESONS AND BARYONS IN NEUTRINO AND ANTINEUTRINO
REACTIONS

[Article by S.A. Voloshin, G.R. Gorgoshidze, A.B. Krebs, and Yu.P. Nikitin,
Moscow Institute of Engineering Physics]

[Abstract] The energy behavior of average multiplicities of charmed mesons
and baryons in neutrino (antineutrino)-nucleon collisions is investigated
on the basis of the quark-parton model using the combinatory quark counting
method for finite energies. The processes underlying the single formation
of charmed particles, which dominate in the region of energies accessible
to study, are investigated. The results of calculating neutrino multi-
plicities of charmed mesons and baryons during charmed quark formation
are analyzed. The possible role of neutrino reactions of charmed hadrons

due to elementary subprocesses of interaction between neutrinos and a
charmed nucleon sea is discussed. Figures 5; references 9: 3 Russian,
6 Western.

INFLUENCE OF MAGNETIC FIELD ON ELECTRICALLY WEAK ANNIHILATION PROCESSES

[Article by Yu.M. Loskutov and V.V. Skobelev, Moscow State University]

[Abstract] Photon and neutron annihilation channels of electron-positron
pairs in a magnetic field are investigated. The influence of the magnetic
field on $e^+e^- \rightarrow \nu\bar{\nu}$ annihilation processes is investigated within the framework
of the Glashow-Weinberg-Salam model in order to shed light on the influence
of strong magnetic fields on astrophysical processes, especially the
evolution of collapsing objects accompanied by strong neutrino radiation.
The probability of single-photon positron annihilation with an electron
that exhibits either monoenergetic distribution or the distribution of a
degenerate Fermi gas is calculated. The probability of neutrino annihila-
tion within the framework of the GVS model is determined, and the contribu-
tion of that channel through the power of the neutrino radiation by magnetic
stars is assessed. Figures 2; references 16: 13 Russian, 3 Western.

MODEL DESCRIPTION OF NEUTRON EMISSION IN HEAVY-ION INDUCED REACTIONS

[Article by R.V. Kzholos and S.P. Ivanova, Consolidated Nuclear Research
Institute]

[Abstract] The increased nucleon yield at small angles and with energies
significantly exceeding those predicted by the statistical model is
investigated within the framework of a model developed earlier by the
authors to describe relative nucleus movement in which it is assumed that
a one-particle mechanism underlies the dissipation of kinetic energy. The
time-varying average field of each of the nuclei excites particle-hole
states in its partner, including states that reside in the continuous
spectrum. The model proposed describes the escape of fast particles during

the initial stage of the reaction. The proposed model is found to describe the high-energy range of the spectrum satisfactorily, while the statistical approach is suitable for the low-energy part of the spectrum. Figures 1; references 14: 6 Russian, 8 Western.

6900/9835
CSO: 1862/231

ORIENTATION SPIN-TENSORS OF COMPOUND FISSILE NUCLEI FORMED DURING NEUTRON CAPTURE

[Article by A.L. Barabanov and D.P. Grechukhin, Institute of Nuclear Energy imeni I.V. Kurchatov]

[Abstract] The orientation spin-tensors of composite fissile nuclei formed during neutron capture by non-oriented and oriented nuclei are investigated for energies of E≲0.5 MeV, for which only the interaction of s- and p-waves with nuclei is significant. Second- and fourth-rank spin-tensors are analyzed. The oriented spin-tensors are found to be insensitive to optical penetrance. It is shown that measurements of the amplitude of the hexadecapole component of the angular distribution of the fragments are sensitive mainly to the density of the p-resonances with spins $J=I+3/2$ in the internal ΔE of the energy spread of the beam of incident neutrons, as well as the fissionability of those resonances. Tables 3, references 24: 13 Russian, 11 Western.

6900/9835
CSO: 1862/231

ANGULAR ANISOTROPY AND CRITICAL ANGULAR MOMENTUM IN NUCLEAR FISSION INDUCED BY LIGHT CHARGED PARTICLES

[Article by S.D. Beyzin, M.G. Itkis, I.A. Kamenev, S.I. Mulgin, V.I. Okolovich, and G.N. Smirenkin, Institute of Nuclear Physics, Kazakh SSR Academy of Sciences]

[Abstract] The angular distributions of the fission fragments of pre-actinide nuclei in reactions with protons and α-particles are analyzed and studied experimentally. The differential nuclear fission cross-sections were measured on beams of α-particles and protons produced by the U-240 cyclotron of the Institute of Nuclear Research of the Ukrainian SSR Academy of Sciences

in the 40-80 and 35-70 MeV bands, respectively. The influence of critical angular momentum on the characteristics of the fission process, and the associated relationship between the contributions of equilibrium and non-equilibrium interaction mechanisms to the reaction cross-section for light charged particles is studied systematically. A semiempirical description is obtained of the critical angular momentum and composite nucleus formation cross-section as a function of the excitation energy and nucleon composition. Tables 2; figures 8; references 33: 16 Russian, 17 Western.

6900/9835
CSO: 1862/231

RECORDING REGISTRATION OF RARE NUCLEAR TRANSFORMATIONS BY DETECTING MULTIPLE NEUTRON EMISSION EVENTS

[Article by G.N. Flerov, G.M. Ter-Akopyan, Ye.A. Sokol, Sh. Sharo, Sh.S. Zeynalov, and M.P. Ivanov]

[Abstract] Nuclear transformations resulting from spontaneous decay or the interaction of cosmic rays are examined. In order to search for terrestrial objects that contain hypothetical superheavy elements it is found necessary to create a neutron detector designed for studying specimens of ores and rocks weighing up to 1 ton that can measure the spatial distribution density of the neutrons in each event. Such a set-up will make it possible to investigate nuclear decays caused by nonconservation of the baryon number. Multiple neutron events caused by nuclear interaction of a neutrino beam from an accelerator is of particular interest. The registration of the multiple neutrons will be of help in experiment. on nucleon decay if that decay has a high probability of leading to multihedron finite states. These advantages can be exploited in registering nuclear decays caused by nN annihilation. Figures 1; references 33: 13 Russian, 20 Western.

6900/9835
CSO: 1862/231

INFLUENCE OF SUPERMOLECULAR STRUCTURE ON ELECTRIC AND PHYSICO-MECHANICAL PROPERTIES OF POLYPROPYLENE

[Article by M.A. Kurbanov, S.A. Abasov, M.M. Kuliyev, A.M. Magerramov, and T.M. Beliyev, Institute of Physics]

[Abstract] An experimental study of amorphous-crystalline polymers was made, for the purpose of determining the influence of its supermolecular structure on its electretic and mechanical properties. Polypropylene, with easily variable form and size of elements of the supermolecular structure, was selected as representative material for this study. Granules of isotactic "Moplen" polypropylene (melting point 443 K, melt index 0.70 g/10 min) were used as raw material. Films 50 mm in diameter and 13-260 μm thick were produced by hot pressing between two polished aluminum plates made of 15 μm foil, under a pressure of 15 MPa at 493 K. Crystallization was effected in two ways, by fast cooling into a sphero-lithic structure at a rate of 2000°C/min in a water-ice mixture and by slow cooling to 275 K at an average rate of 2°C/min. Electrets were produced by heat treatment in a constant electric field, with the polariza-tion temperature varied over the 363-433 K range, the electric field intensity varied over the $(0.2-2) \cdot 10^7$ V/cm range, and the polarization time varied up to 3 h. Mechanical and electrical measurements, also microstructural examination under an MIM-7 metallographical microscope and x-ray phase analysis, reveal that changes in the physical structure influence particularly the electretic properties and the mechanical life of this material as well as the quantitative relation between charge buildup and drop of tensile strength upon application of an electric field. Material with spherolithic structure was found to have generally worse characteristic than material without supermolecular formations. Figures 7; references 10: all Russian.

POLARIZATION EFFECTS IN BIREFRINGENT FIBER-OPTIC WAVEGUIDES WITH ELLIPTICAL BOROSILICATE SHEATH

[Article by V.V. Grigoryants, A.N. Zalogin, G.A. Ivanov, V.A. Isayev, S.M. Kozel, V.N. Listvin, and Yu.K. Chamorovskiy, Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow]

[Abstract] A study of birefringent single-mode fiber optics with a strong polarization anisotropy and with elliptical borosilicate sheaths around the quartz glass cores was made, such fiber-optic waveguides being considered for use as depolarizers of incident radiation and as tunable delay lines. The purpose was to experimentally determine the wavelength dependence and the temperature dependence of the difference $\Delta\beta$ between the two propagation constants, the theoretical relation being

$$\Delta\beta = ck\Delta\alpha(T - T_0)\frac{1 - e}{1 + e} \quad (c = 0.33$$

constant determined by the linear combination of quartz glass parameters, k- wave number, T- temperature, T_0- softening point of borosilicate glass, $\Delta\alpha$- difference between the thermal expansion coefficients of the two glasses, e= a/b - ratio of ellipse semiaxes). Elliptical sheaths were formed by mechanical grinding and subsequent rounding of cylindrical ingots which had been produced by the Metal Chemical Vapor Deposition method. Measurements were made by the method of birefringence in a phase plate, with a He-Ne or semiconductor laser and a monochromator respectively on the entrance side and on the exit side of the optical fiber. Beats between LP_{01} polarization modes as well as between LP_{01} and LP_{11} space modes were recorded with the aid of equipment including also the appropriate polaroid-lens optics on both sides of the fiber, a photoreceiver with a synchronous detector behind the monochromator output lens, and a transducer electromagnetic with an audio-frequency oscillator and a power amplifier. Figures 6; references 9: 2 Russian, 7 Western.

UDC 621.373.826.038.823

GENERATION AND AMPLIFICATION OF SUBPICOSECOND ULTRAVIOLET RADIATION PULSES BY MEANS OF EXCIMER LASERS

GENERATION AND AMPLIFICATION OF SUBPICOSECOND ULTRAVIOLET RADIATION PULSES BY MEANS OF EXCIMER LASERS

[Article by S.A. Akhmanov, V.M. Gordiyenko, M.S. Dzhidzhoyev, S.V. Krayushkin, I.A. Kudinov, V.T. Platonenko, and V.K. Popov, Moscow State University imeni M.V. Lomonosov]

[Abstract] Subpicosecond pulses of ultraviolet radiation (wavelength $\lambda_1 = 308$ nm) were produced in an experiment with two excimer (XeCl) lasers, a laser-generator transversely pumping a laser-amplifier. The apparatus included also a solid-state (YAlO$_3$) master laser with passive mode locking and electronic Q-switching, a dye (C160) laser-generator tuned to the $\lambda_2 = 616$ nm wavelength, a fiber-optic pulse compressor with a diffraction grating (1200 lines/mm), and a dye (C160) laser-amplifier. The solid-state master laser generated 20 ps pulses and its second-harmonic radiation pumped the dye laser-generator. Pulses of 6 ps duration emitted by the latter were compressed by the diffraction grating, after their spectrum had been widened to 100 cm^{-1} in the 5 m long single-mode optical fiber. The resulting narrow pulses, of approximately 1 nJ energy, were amplified by the 2-stage excimer laser-amplifier. The excimer laser-generator pumped the excimer laser-amplifier with 2 ns pulses and, also acting as a strobe, extracted one ultrashort pulse from a train of five such input pulses. Ethanol solution of malachite green was used for saturable decoupling filter between the two excimer lasers. The excimer laser-amplifier, with an 80 cm long active medium, put out pulses of 350 fs duration and 2 μJ maximum energy, thus with a power of almost 6 GW. The authors thank A.A. Podshivalov for assisting in the experiments. Figures 2; references 4: 3 Russian, 1 Western.

2415/9835
CSO: 1862/49

USE OF HIGH-CURRENT ELECTRON BEAM WITH VARIABLE FREQUENCY MODULATION IN
COLLECTIVE ION ACCELERATOR

[Article by A.Sh. Ayrapetov, Institute of Physics imeni P.N. Lebedev,
USSR Academy of Sciences, Moscow]

[Abstract] Varying the modulation frequency of a high-current electron beam
rather than the space period of its current distribution in a corrugated
vacuum tube is proposed as means of controlling the phase velocity of an
electron space-charge wave for collective acceleration of ions. Linear
variation of the modulation frequency in an electron tube with uniform
corrugation increases the ion acceleration at the cost of decreasing the
mean ion beam intensity, an electron space-charge wave entraining ions at
the beginning of an electron pulse only, because of the fast variation of
its modulation frequency and thus also of its phase velocity. This
deficiency can be partially overcome by distribution of ions along the
accelerator tube, one way being to use preionized residual gas as the ion
source. The ion energy will then be proportional to the length of the ion
path in the accelerator and a nearly uniform energy spectrum of ions will
be attainable for various applications such as production of high-power
neutron fluxes, breeding nuclear fuel, radiation therapy, or shock compres-
sion and heating of materials. An electron beam capable of such collective
acceleration of ions from 1 MeV to 1 GeV (mean ion energy 500 MeV) with
25% efficiency must have a minimum current of 10 kA and a maximum diameter
of 1 cm, with the current modulation frequency varied from 2-3 GHz to
6.3 GHz. The author thanks A.A. Kolomenskiy, A.N. Lebedev, and B.N. Yablokov
for fruitful discussions. References 7: 5 Russian, 2 Western.

2415/9835
CSO: 1862/19

SCATTERING OF X-RAYS BY NONHOMOGENEOUS SURFACE UNDER CONDITIONS OF TOTAL
EXTERNAL REFLECTION

[Article by A.V. Andreyev, S.A. Akhmanov, and Yu.V. Ponomarev, Moscow
State University imeni M.V. Lomonosov]

[Abstract] Reflection of x-rays by a nonhomogeneous surface is analyzed on
the basis of theory and experiments, to explain the appearance of nonuniform
x-ray waves in vacuum. Theoretical calculations are made for a nonhomogeneous

surface layer, assuming that its electron concentration is a random function of the radius-vector so that its dielectric permittivity can be expressed as the sum of a fluctuation component which is a function of the radius vector and an average component which is a function of the longitudinal coordinate. Into account is taken sliding of the wave at angles depending on which scattering and regular refraction or total external reflection can occur. The general expressions for the amplitudes of both regular and scattered fields are evaluated for the specific cases of a randomly rough surface and a surface with volume inhomogeneities under the surface, also for a grating with fluctuating pitch and line width. Nonuniform vacuum waves are considered as a corollary. Experiments were performed with three diffraction gratings cut in aluminum films which had been deposited by vacuum evaporation on glass substrates having a Class 14, amorphous films being used so as to avoid dynamic dispersive excitation of parasitic surface waves. Two gratings had the same period d = 100 μm but different line widths, with both depth and width dispersion of the wider lines being larger. The third one was an optical diffraction grating with a period d = 5 μm. Scattering of CuK_α-line radiation was observed in a bicrystal x-ray spectrometer with a Si monochromator and (111) reflection. Integral and diffential reflection patterns were recorded, with the locations of diffraction peaks depending on the sliding angle of the incident wave and the intensity of interference peaks depending on the wave exit angle. The results confirm the mechanism of generation of nonuniform vacuum x-ray waves and provide the basis for a method of determining the statistical characteristics of nonhomogeneous 10-1000 Å thick surface layers. Figures 3; references 7: 5 Russian, 2 Western.

2415/9835
CSO: 1862/262

UDC 534.1:537.228.1

PROPAGATION OF LONGITUDINAL ELECTROELASTIC WAVES THROUGH LAYERS OF REGULARLY STRATIFIED MEDIUM

[Article by N.A. Shul'ga, Institute of Mechanics, UkSSR Academy of Sciences, Kiev]

[Abstract] The problem of propagation of electroacoustic waves through a regular multilayer medium is formulated in the quasi-steady approximation for a piezoceramic material consisting of alternately stacked two kinds of layers with different physico-mechanical properties, a-1 layers of one kind having the same thickness h_1, h_2 respectively. The corresponding system of four first-order differential equations for two mechanical quantities (displacement, stress) and two electrical quantities (induction, potential), assuming each quantity to be an $e^{-j\omega t}$-function of time, is reduced by four

respective conditions of continuity first to an infinite system of homogeneous algebraic equations and then to a system of four such equations in both a vector and a scalar. The scalar eigen-values are found by equating the determinant of this system to zero, which then yields the dispersion law for the propagating waves. Their average velocity is determined from that dispersion law in the long-wave approximation. References 6: all Russian.

SPHERICAL DETONATION WAVES IN VISCOPLASTIC SOLID MULTICOMPONENT MEDIUM

[Article by G.M. Lakhov, I.A. Luchko, V.A. Plaksiy, N.S. Remez, and
A.V. Krymskiy, Department of Detonation Geodynamics, Institute of Geophysics,
UkSSR Academy of Sciences, Kiev]

[Abstract] Propagation of spherical underground detonation waves is analyzed, assuming a ground not saturated with water and describable by the model of a porous viscoplastic solid multicomponent medium. The analysis is based on the equation of deformation for a body of such a material according to which the rate of change of volume is proportional to the initial volume and to the difference of two terms, each term a different function of the pressure and the relative change of density, in addition to the equations of motion. The ground and the products of the detonation reaction are treated as continuous media so that the respective equations of motion reflect conservation of both mass and momentum, the products of the detonation reaction being also assumed to expand isentropically. The problem has been solved by the numerical method of finite differences, using the M.L. Wilkins "cross" scheme and a modification of the Neumann-Richtmeier stability criterion. The solution yields a dependence of wave parameters on the loading rate. Numerical results for detonation of cast trinitrotoluene in sand of medium grain size and in wet clay agree closely with experimental data. Figures 5; references 14: 12 Russian, 2 Western (both in Russian translation).

RECOVERY OF METALS FROM OXIDES USING LASER HEATING

[Article by D.T. Alimov, I.V. Yedvabnyy, and P.K. Khabibullayev]

[Abstract] A theoretical study is made of the dynamics of laser heating of specimens of metal oxides, as well as the thickness of the layer of recovered metal, considering laser heating as well as the intrinsic energy release of the chemical reaction. A function is derived that describes, in compact form, laser recovery of metal oxides with small heating radiation power and correspondingly low target temperature. Formulas are derived that describe deviations from that function that occur at higher temperatures. Figures 2; references 4: all Russian.

SELF-SUSTAINING VOLUME DISCHARGE INITIATED BY X-RADIATION IN He-Xe-HCl MIXTURE IN LONG INTERELECTRODE GAPS

[Article by V.G. Geyman, S.A. Genkin, Yu.D. Korolev, and G.A. Mesyats, Institute of High-Current Electronics, Siberian Department, USSR Academy of Sciences, Tomsk]

[Abstract] Excitation of a discharge over a 10 cm long interelectrode gap in He:Xe:HCl = 4000:10:1 and He:Xe:HCl = 1000:10:1 mixtures was studied, also self-sustainance of such a discharge within $(3-7) \cdot 10^3$ cm^3 large plasma volumes. Discharge inside a chamber with walls of acrylic glass was initiated by preionizing the gas with x-radiation from a low-energy pulse source and subsequently applying 70 kV across the electrodes from a 0.1-0.4 μF capacitor bank, its discharge being synchronized within ± 20 ns with peaking of the x-radiation pulse. Plasma glow at the wavelength of the XeCl* exciplex complex (λ = 308 nm) was observed. Evaluation of voltage, discharge current, and glow intensity oscillograms indicates the feasibility of self-sustaining discharge over long interelectrode gaps, most of the glow energy during the volume discharge stage being extractable and thus available for pumping excimer lasers. The time lag from voltage zero-crossover to current zero-crossover indicates formation of a spark channel, as a result of plasma breakup in the plasma column, with an attendant buildup of an inductive impedance. Figures 3; tables 1; references 8: 6 Russian, 2 Western.

CHARACTERISTICS OF INTRACAVITY RAMAN RADIATION IN COMPRESSED OXYGEN

[Article by N.V. Kravtsov and N.I. Naumkin, Scientific Research Institute
of Nuclear Physics, Moscow State University imeni M.V. Lomonosov]

[Abstract] An experimental study of intercavity stimulated Raman radiation in
compressed oxygen was made, including measurements at the frequency of funda-
mental radiation (wavelength λ = 0.69 μm) as well as at the frequency of the
first Stokes component (wavelength λ = 0.78 μm). The laser resonator formed
by plane mirrors had a high Q-factor at both frequencies and also at the
frequency of the first Stokes component in compressed hydrogen (wavelength
λ = 0.98 μm), the same experiment being performed with compressed hydrogen
for comparison. Inside the resonator cavity were placed in sequence a Q-
switching nonlinear filter, a ruby crystal serving as the active laser
medium, and a vessel with compressed oxygen inside a solenoid producing
a longitudinal magnetic field. Two telescopic biconvex with a focal length
of 35 cm each were inserted: one between the ruby laser and the oxygen
cell, one between the oxygen cell and resonator exit mirror. Both resonator
mirrors had a reflection coefficient higher than 0.99 for radiation at the
ruby wavelength and approximately 0.80 for the first Stokes component.
Some radiation from the exit mirror was passed through a biconcave lens to
a Fabry-Perot interferometer, then through a light filter and a collimator
to an image converter for a photo camera. Some radiation was diverted
successively by two light-splitting plates for extraction of the two
sought radiation components by appropriate interference filters onto a
photocell each and then to an oscillograph. The results reveal Raman
radiation in compressed oxygen with a much wider spectrum at the Stokes
frequency than at the fundamental frequency, radiation at the combination
frequency consisting of ultrashort pulses with the pulse period equal
to the resonator passage time and thus with partial self-locking of modes.
Application of a magnetic field increased the probability of self-locking
in compressed oxygen, but hardly at all in compressed hydrogen, a nonuni-
form magnetic field causing the spectrum at the Stokes frequency to widen
and the ultrashort pulses to become still shorter. In compressed hydrogen
the spectrum of intracavity stimulated Raman radiation at the combination
frequency was a wide as the spectrum of the pumping radiation, a smooth
monopulse of 50 ps duration being generated at the Stokes frequency. In
compressed oxygen, therefore, it is possible to control the characteristics
of stimulated Raman radiation by means of a magnetic field. Figures 2;
references 6: 5 Russian, 1 Western (in Russian translation).

SELECTIVE LASING IONIZATION OF ATOMS OF SOLID SUBSTANCES ATOMIZED BY ION BEAM

[Article by S.V. Gorbunov, I.V. Zakurdayev, M.L. Muchnik, A.I. Suslov, G.A. Sheroziya, and V.A. Shishlakov]

[Abstract] An experimental apparatus has been built for analysis of solid surface layers by laser spectroscopy involving atomization with an ion beam and subsequent selective lasing of atoms. The apparatus consists of a Cu-vapor laser, a tunable dye (LZhI-504) laser, a beam splitting mirror, two rotatable quartz prisms, three focusing lenses, a frequency doubling KDP crystal, a vacuum chamber passing the atom beam, an ion gun, an ion filter with power supply for rejection of scattered and secondary ions, consisting of two grounded diaphragms and two electrodes under voltage, an extractor of selectively ionized atoms, a secondary-electron multiplier for ion count, a recording detector, and a square-wave pulse generator. The surface of a specimen is inclined at $45°$ to the ion-optical axis of the ion gun and at $45°$ to the axis of the atom beam between the two diaphragms. The ion-optical axis of the atom extractor and the optical axis of the laser beams lie in a plane perpendicular to the atom beam and 3 cm away from the atomized solid surface. In an experiment the Cu-vapor laser emitted pulses at $\lambda_1 = 510.6$ nm wavelength of 10 W average power for pumping the dye laser and pulses at $\lambda_2 = 578.2$ nm wavelength of 12 W average power for the second ionization stage, all pulses of 20 ns duration with a repetition rate of 8 kHz. The dye laser emitted radiation at $\lambda_3 = 607.87$ nm wavelength, which the KDP crystal converted to radiation at $\lambda_4 = 303.94$ of 15 mW average power. With this equipment was analyzed the neutral component of poly-crystalline In atomized from the surface by Ar^+ ions. Measurements revealed a linear dependence of the photoion current on the ion gun current over the $0-0.3$ µA range of the latter and eventual saturation with further increase of the latter up to 2-3 µA, also a similar dependence of the photoion current on the atom extractor voltage and of the atomization factor on the energy of bombarding ions. Figures 3; references 5: all Russian.

INTERBAND PAIRING AND SUPERCONDUCTIVITY OF SYSTEMS WITH HEAVY FERMIONS

[Article by O.V. Dolgov and D.I. Khomskiy, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, and Ye.P. Fetisov, Moscow Institute of Engineering Physics]

[Abstract] Superconductivity of materials such as compounds of rare-earth metals and of actinides, with heavy fermions at low temperature, is interpreted on the basis of the interband singlet pairing model. Calculations for $CeCu_2Si_2$ and UPt_3, including Condo interaction, and experimental data on the "de Haas - van Alfven" effect revealing the presence of light d-electrons along with pairing heavy f-electrons confirm the validity of this model. It correctly describes thermodynamic and electromagnetic characteristics of such superconductor materials. References 9: 3 Russian, 6 Western.

THEORETICAL PHYSICS

CHROMODYNAMICS: THEORY OF STRONG INTERACTIONS

[Article by I.V. Andreyev, Institute of Physics imeni P.N. Lebedev,
USSR Academy of Sciences]

[Abstract] Both short-range interaction physics and long-range interaction
physics are reviewed, with chromodynamic corrections. Quantum chromodynamics
as a theory of strong interactions involving quarks and gluons has been
constructed on the basis of an adequate vacuum model. Theoretical methods
of quantum chromodynamics developed so far include the rule of sums, using
the Fourier transform of the product of currents, and phenomenological
methods based on interaction-potential quark models or hadron jet models,
a special one among these methods being that of effective chiral Lagrangians.
A new approach, intermediate between theoretical and experimental physics
with computer-aided calculations on a grid replacing the four-dimensional
continuum of points in a Euclidean space, is now gaining acceptance to the
other ones. With the physical elements of the theory of strong interactions
already established, mathematical methods still need to be developed and
refined for quantitative analysis of intricate dynamic systems. Figures 8;
references 35: 6 Russian, 29 Western.

TOPONIUM

[Article by I.M. Dremin, Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences]

[Abstract] Theoretical predictions and their physical implications pertaining to the toponium system are reviewed, following a recapitulation of the properties of the lighter charmonium and bottomium systems. Models of the interaction potential and their general characteristics are derived from the Schrödinger equation for a nonrelativistic system of two bodies with spherically symmetric coupling forces, of particular interest being here the extreme two cases of a weak distance dependence and of a near approach to Coulomb interaction. Experimental data on highly inelastic processes typical of the toponium system have extended the heretofore anticipated range of distances over which quark interactions will occur in accordance with those models. Next is considered the possibility of toponium spectroscopy for verification of hypothetical quark properties such as asymptotic freedom, transition from current quarks to constituent quarks, and independence of the interaction potential on the flavor. Three basic possible paths of toponium decay are followed through schematically and quantitatively, with annihilation of quarks or with transition to a lower state, also decay modes with generation of supersymmetric partners for plain particles either by annihilation of the top-quark with antiquark and attendant transformation of a gluon into a gluino pair or by decay of a solitary quark. The toponium system can be used for determining the structure of quarks in terms of the chromodynamic Lagrangian, for determining how many kinds of neutrino exist in nature, for measuring the Weinberg angle involved in the lepton distribution, for determining the energy spectrum of hadrons from the τ-lepton decay, and for establishing the asymmetry of "forward-backward" leptons and of quark jets. Polarization of toponium jets, interference of a top-quark and a Z^0-boson, and generation of toponium systems are items to be explored, after such a system has been hopefully discovered in an SLC or LEP accelerator. The author thanks Ye.L. Feynberg, M.A. Shifman, and V.A. Khoze for valuable comments. Figures 15; references 123: 17 Russian, 106 Western.

- END -